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POSITIONING

IN

RADIOGRAPHY

BY

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Acknowledgments: First Edition

In acknowledgment of my indebtedness to the many interested in radiography who have generously contributed toward the production of this book, I would express my thanks to the following for the advice, the loan of films, and for the many facilities which have been given me for seeing certain work in progress in various hospitals, and also for the use of apparatus and for many kindnesses and encouragements:—

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Mr. Cuthbert Andrews, Messrs. Philips Metalix Ltd., and the Medical Supply Association Ltd., for accessories; Messrs. A. E. Dean & Co. Ltd., for their ward mobile unit; Messrs. Newton & Wright Ltd., for the tomograph; The Solus Electrical Co. Ltd., for the kymograph; The Victor X-ray Corporation for mobile and ward units; and Messrs. Watsons (Electro-Medical) Ltd., for the Lysholm skull table and accessories.

I would also record my grateful thanks to Mrs. M. Coburn for her helpful comments made from the point of view of the teacher, and also to Mr. T. H. Wright, M.B.E., for much kindly criticism and advice during the reading of the proofs.

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A special word of thanks is due to Dr. H. Courtney Gage, who has been unsparing in the help and advice which he has given me; particularly am I grateful for his very careful reading of the proofs and for the many invaluable suggestions which he has made.

I also wish to express my gratitude to the Directors of Ilford Limited for allowing me to undertake much of the preparation work in their Radiographic Technical and Demonstration Department at Tavistock House; without this and the encouragement which they have given me the task would not have been possible. The majority of the photographs and many of the radiographs were made in the above department.

K. C. CLARK.

November 1938.

Acknowledgments: Second Edition

The second edition of "Positioning in Radiography" contains much new matter and many additional illustrations.

New sections on X-ray Screen Photography and Seriescopy have been added, and the section dealing with Foreign Bodies has been partly rewritten and extended by the inclusion of notes on anatomical location and further localisation methods. The new matter comprises 30 pages and 125 illustrations.

During the preparation of this edition I have again enjoyed the generous co-operation of many experienced and well-known X-ray workers and others. I have had the opportunity of seeing further specialised techniques and receiving much helpful advice, and have been able to collect a number of interesting radiographs for the new illustrations, for all of which I warmly thank Dr. J. F. Brailsford, Dr. Philip Ellman, Mr. E. S. Evans, Dr. Richard Fawcitt, Mr. F. P. Fitzgerald, Dr. F. Campbell Golding, Mr. B. H. Humble, Major R. S. MacHardy, Dr. Erik Lysholm, Dr. R. E. Roberts, Dr. B. Stanford, Mr. R. H. Jocelyn Swan and also Miss M. Gamble, Miss B. A. Hall, Miss M. V. Ray, Mr. John Scott and Miss J. Wright. I am also indebted to the Editors of *The British Journal of Radiology* for permission to use two calculation tables which appeared in the issue of November 1939, and to Messrs. H. K. Lewis & Co. Ltd. for kindly allowing me to use an illustration from "A Text Book of X-ray Diagnosis," Volume II, by British Authors.

For so kindly allowing me the use of certain apparatus and for their ready advice I would thank Mr. Cuthbert Andrews for the additional mobile unit and assistance with the screen localiser; Messrs. Newton & Wright Ltd., for the seriescope; Mr. W. E. Schall, for the Scott localiser; and Messrs. Solus Electrical Co., for the localisation spectacles.

I would acknowledge my indebtedness to Dr. G. R. Mather Cordiner for his valued advice and for placing at my disposal a number of new illustrations which have added considerably to the interest of the section on the alimentary tract.

To Colonel D. B. McGrigor, O.B.E., I am grateful, also, for his advice on the section dealing with Foreign Bodies, and particularly for his help in connection with the screen localiser and the localisation spectacles of his design; and I am much indebted to Dr. H. M. Harper and Mr. W. Watson for their very kind assistance in the revision of this section.

Again I have had the benefit of the invaluable assistance of those who have been so patient as to read the proofs, and in this connection I am glad to have this opportunity of recording my grateful thanks to Dr. H. Courtney Gage who also lent a number of interesting illustrations, to Professor H. A. Harris and to Mr. T. H. Wright, M.B.E.

And again I am greatly indebted to the Directors of Ilford Limited, who have been good enough to undertake the publication of this second edition during so difficult a period.

K. C. CLARK.

November 1940.

Acknowledgments: Fourth Edition

The publication of the fourth edition of "Positioning in Radiography" has given me the opportunity of rewriting Section 33, and of adding considerable new matter and illustrations to several other sections.

I have again received much practical advice and permission to use new illustrations and I am glad to be able to acknowledge my indebtedness to Major F. H. Bonnell, R.C.A.M.C., Dr. G. R. Mather Cordiner, Major D. C. Eaglesham, R.C.A.M.C., Mr. F. P. Fitzgerald, Captain P. P. Hauch, R.C.A.M.C., Dr. Peter Kerley, and Mr. Eric Lloyd; and also to Miss M. R. Bell and Mrs. O. Wilkinson; and to the Editors of *The British Journal of Radiology* and the Editors of *Lancet* for kindly allowing me to use illustrations which appeared in the issues of those journals of March 1944, and August 15, 1942, respectively.

Also I am indeed most grateful for the continued valued advice of Dr. H. Courtney Gage and for the generous assistance of Mr. T. H. Wright, M.B.E.

I am greatly indebted to the Directors of Ilford Limited for having made possible the publication of the fourth edition and for having given me the facilities necessary to enable me to complete the work.

K. C. CLARK.

May 1944.

Preliminary Note

The object of this book is to present in as concise and practical a form as possible to the student and to those practising radiography the essentials of radiographic technique. It is not claimed to be a complete treatise, and since the aim has been to make it a practical book, theoretical considerations have been omitted as far as possible, and the subject discussed from the point of view of the practical worker. The technique given and illustrated is, indeed, with very few exceptions, that actually practised by the writer.

Positioning is, perhaps, the all important feature in radiography. Correct positioning has been illustrated photographically, and the radiographs resulting from such positioning have been included, together with occasional line diagrams and photographs of the dried bones. The positions are described in simple language, and a selection of suitable exposure factors is shown for each position.

Both new and old anatomical nomenclatures are employed, as both are in general use.

No great effort has been made to discuss abnormalities other than those encountered by the general worker, as it would obviously be impossible to cover the field completely.

The factors contributing to the success of an X-ray Department are equipment, technical procedure and the interpretation of the radiograph. This book does not enter into any discussion on electrical equipment; it does touch, however, upon the various accessories most commonly used. An endeavour has been made to define a systematic method of procedure in technique, bearing in mind the fundamental purpose in view. Radiographers are not concerned with the interpretation of the radiograph, and are not expected to express an opinion upon, still less to assume responsibility for, medical diagnosis; that phase, therefore, is not within the scope of this book

APPARATUS AND TECHNIQUE EMPLOYED

A great number of the radiographs have been taken in the Ilford Radiographic Department. Others have been obtained from various sources, and due acknowledgment is made. In all except a few instances the radiographs have been reproduced from negative prints in order that, within the limitations of mechanical reproduction, their appearance may approach as nearly as possible to that of the actual radiograph.

Unless otherwise indicated, the exposure factors quoted apply to a four-valve unit, using a 6-kilowatt tube or a rotating anode tube, both of the shock-free type. Alternative exposure factors given apply to a 30/90 or a 15/90 ward mobile unit, to a 10-milliampere portable unit, and to a 10-milliampere dental unit, each unit having been carefully tested for output to ensure the reliability of these factors as applied to subjects of specified size and type and under standard developing conditions. For each position shown complete exposure data are given, namely, kilovolts (peak), milliampere-seconds, anode-film distance, intensifying screens (when used), localising cone, type of grid (when used), size of film, type of developer used under standard conditions, and size of subject. The relative exposure factors given in each section are correct for a subject of the proportions quoted, and may be generally adjusted to the individual patient in any similar investigation. Where alternative conditions are given they are such as will result in a suitable quality of radiograph.

Anode-film distance has been varied according to position of subject and to unit employed—for grid exposures it ranges from 28 inches to 48 inches; for short-distance technique it has been reduced to 10 or 15 inches; and for teleradiography has been increased to 60 inches and 72 inches. Non-screen technique has been applied wherever possible, use being made of Ilfex films, these being specially prepared for use without intensifying screens.

Both the curved and the flat types of Potter-Bucky diaphragm have been used, and the stationary grid introduced wherever suitable. In using this equipment it should be borne in mind that, as compared with the duration of exposure applicable to the screened film without the grid, three to four times the exposure is required when using the stationary grid, depending on type, and four times for the standard Potter-Bucky

diaphragm. The new high-speed grid of the latter type is essential for short exposure work, and possesses a high standard of efficiency.

Localising cones have been used throughout in the preparation of the illustrations, although they are not shown when the inclusion of tube and subject at the correct anode-film distance would have resulted in an unduly small image of the subject. It is not possible to over-emphasise the importance of restricting radiation to the smallest possible area of the region under examination or, alternatively, to the size of film used. In the screening stand the flat, rectangular diaphragm replaces the localising cone, and should be used at the smallest suitable aperture for both screen examination and radiographic exposure.

White lines have been drawn on the photographs to indicate the direction of the central or normal ray, peripheral rays also being sometimes shown, and in many instances a black spot on subject and radiograph indicates the tube centring point.

It is essential that the worker should possess a knowledge of pathological conditions and thus be able to translate intelligently what may often be very brief instructions into radiographs of the necessary quality, correct position and location. This knowledge, of particular importance in the investigation of progressive bone abnormalities, is also of great service in enabling examination to be limited to what is essential. Although, for example, in a case of rickets, all long bones may be asked for, single antero-posterior views from shoulder to wrist, and from hip to ankle, may be found to give all the information required, and what might have appeared to be a somewhat extensive examination may be carried out with economy of time and material and of far greater importance of discomfort to the patient.

It need hardly be mentioned that the comfort of the patient should be the first consideration at all times. It should be the guide in the choice of posture for the examination, and all care should be taken in ensuring immobilisation. Adequate warmth in the X-ray Department should never be wanting, and an apprehensive patient may very often be soothed and reassured by a little explanation, and particularly by being asked to collaborate in the examination.

The necessity of care in identification of radiographs has been stressed in the following pages. Use should be made of right and left markers at all times and examination should not be regarded as complete without full record being made of the date, name and serial number, and also, where applicable, the positioning of the patient and the intervals at which the films are exposed.

A brief history of each patient should also be recorded.

Brief mention may be made of the qualities desirable in a radiograph.

Density and contrast, perhaps the first two qualities to be noticed on viewing the film, should always be adequate. The flat negative, lacking depth, may fulfil its purpose in certain circumstances, but it may not show all that should be seen. On the other hand, over contrast– particularly regional contrast– is a greater evil, and the aim should be so to adjust exposure factors that variation in regional densities may be suppressed and the film show a reasonably even degree of contrast over the whole field.

Definition, essential in all films, is perhaps the one quality which may be said to be affected by every component and factor in the making of the radiograph. Of first importance, however, is the size of the focal spot, the smaller the spot the finer the detail obtained.

While some diffusion-distortion or shadow spread is always present— and, in certain cases, turned to use– it may be reduced to a minimum by avoiding the use of a short anode-film distance wherever possible and by the adoption of the shortest possible relative subject-film distance. True distortion, on the other hand, may be prevented by correct alignment of film, subject and anode.

All these qualities are affected by practically every factor in the production of the radiograph– high-tension generator and its control, tube, cone, anode-film distance, exposure in terms of kilovoltage, milliamperage and time, subject immobilisation, grid, intensifying screens, type of film, developer and development; each plays its part, and the careful worker will, therefore, be acquainted with the characteristics of his apparatus, balancing values one with another as the circumstances of each examination demand.

Detailed information regarding exposure factors is given in Supplement 2, pages 499 to 501.

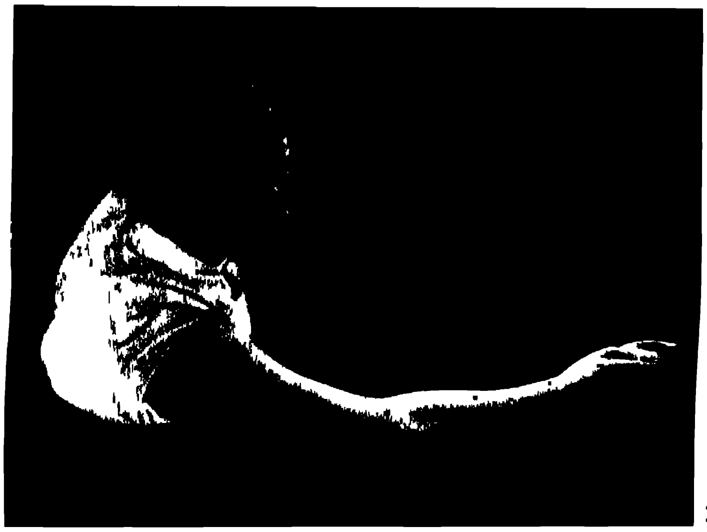
Contents

SUPPLEMENTS

SECTION 1

Upper Extremity

1



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3

SECTION 1

UPPER EXTREMITY

The upper extremity is more frequently radiographed than any other region of the body. In routine work little thought is given to what is generally considered radiography in its most elementary form, and the resulting films often leave much to be desired. For this reason the upper limb is dealt with in some detail.

For the examination of the upper extremity the whole limb is placed on the X-ray couch, with adjacent joints on the same plane as the joint being radiographed.

In the *antero*-posterior (A.P.) position the arm is supinated, i.e., lying with the palm of the hand facing upward, the elbow extended and the shoulder well down, the tube being centred from above the couch **(1)**. Should the under-couch tube be employed for this position the radiographs will be termed *postero*-anterior (P.A.) views.

In the lateral position the elbow is flexed, with the palm of the hand at right-angles to the couch, the forearm being then described as half-supinated or lateral.

When a postero-anterior view is taken of the *hand* and *wrist*, the elbow is flexed, but the forearm is pronated, i.e., rotated until the palm of the hand is in contact with the film, and the tube centred from above **(3)**.

Centring points for wrist, forearm and elbow are indicated by black spots **(1, 2)**.

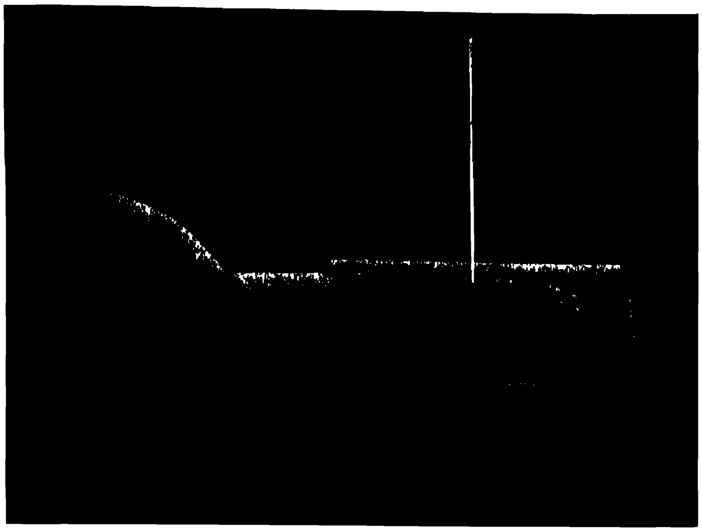
Relaxation of the subject is important. Immobilisation is carried out by the use of non-opaque pads of *cotton wool and loosely filled sandbags placed above and below the joints, and too much emphasis cannot be placed on the importance of the comfortable adjustment of the limb.

Where splints, plaster or voluminous dressings have been applied, measurements may be taken from the normal limb, and the exact centring point obtained **(3)**.

The normal limb is very frequently taken for comparison with the injured limb, especially in children. It is important that both limbs be taken from the same aspect and under similar conditions.

In many instances in the following text, the examination of the *normal* subject is followed by examination of certain injuries and pathological conditions, to indicate that by adjustment of the position of tube and film equally satisfactory views may be obtained **(38, 52, 54**, etc.).

Lambs wool may be used in place of *cotton* wool.



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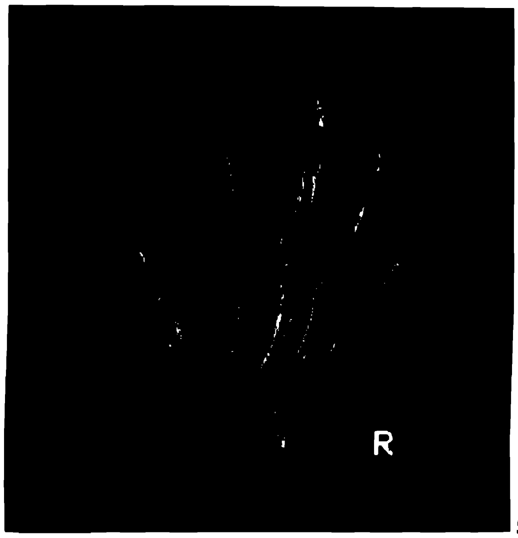

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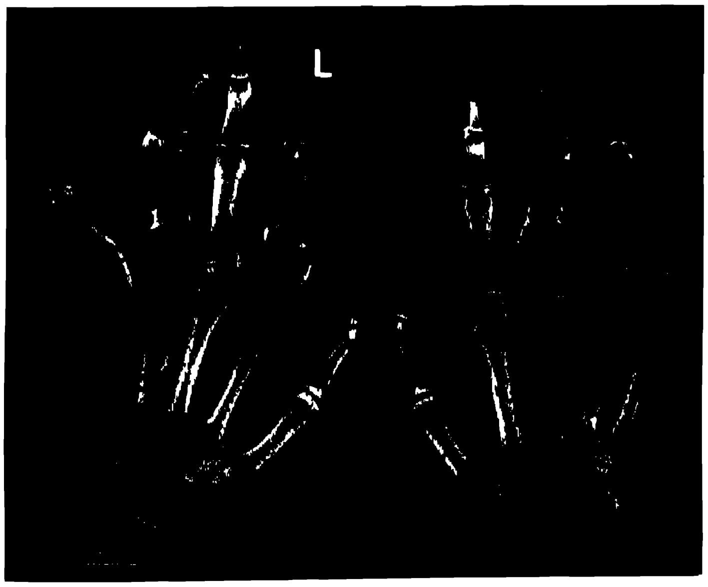

5a

Upper Extremity: Hand

A small extension cone has been used to cover each size of film. Unless otherwise stated, it should be understood that the tube is straight, with the central ray at an angle of 90 degrees to the film, and at an anode-film distance of from 30 inches to 36 inches. Exposure factors are quoted in each position, with and without intensifying screens. These factors refer to a large-boned adult subject. For smaller subjects the milliampere seconds should be reduced by from 25 per cent. to 50 per cent.

ANATOMICAL NOMENCLATURE

As both old and new anatomical terminologies are in general use the following alternative terms used in this section are quoted for guidance:—

New	Old
Navicular	Scaphoid
Lunate	Semilunar
Triquetral	Cuneiform
Pisiform	Pisiform
Greater Multangular	Trapezium
Lesser Multangular	Trapezoid
Capitate	Os magnum
Hamate	Unciform.

Hand: General Views

These positions demonstrate the carpals, metacarpals and phalanges, their inter-articulations and the wrist joint.

POSTERO-ANTERIOR

The forearm is placed on the table in pronation, with the fingers extended and separated to bring them into close contact with the film.

CENTRE over the upper third of the third metacarpal.

(4, 5)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	21	13	30″	Ilfex	—	—
45	66	40	30″	Ilfex	—	—
45	8	5	36″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in. or 10 × 8 in.

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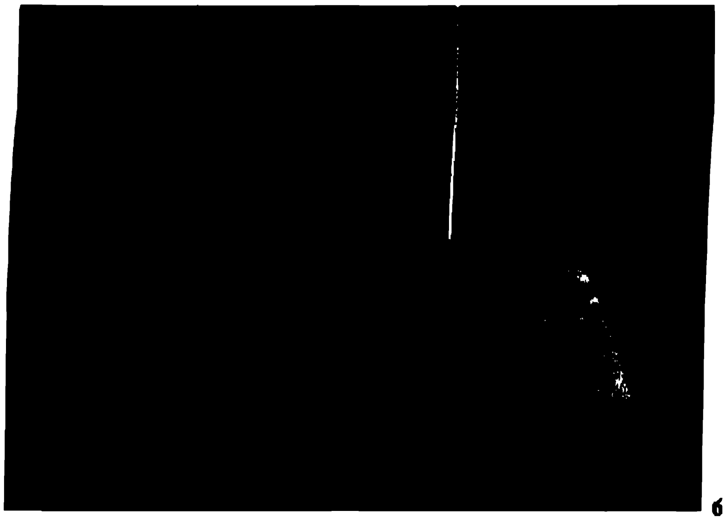

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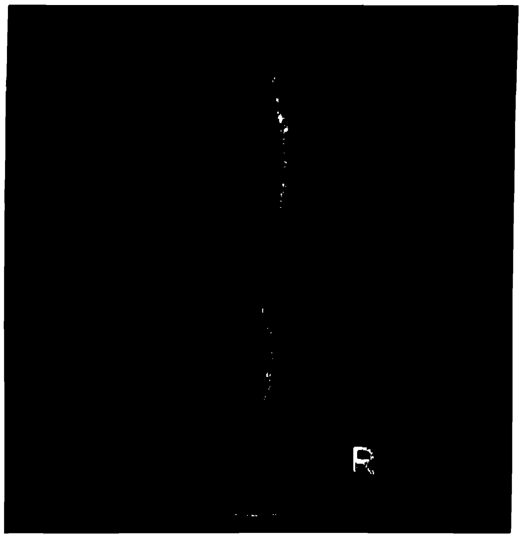

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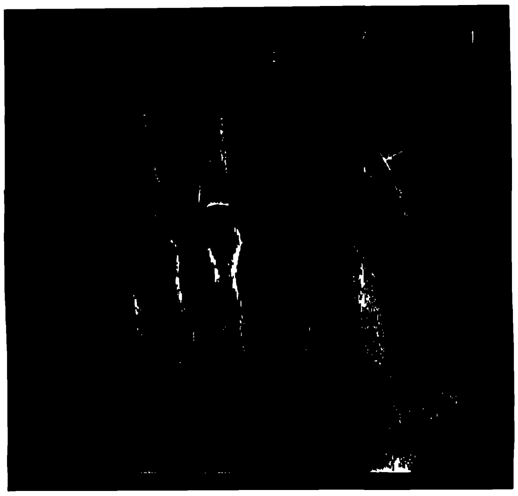


7a

Upper Extremity: Hand

POSTERO-ANTERIOR (*continued*)

Radiograph **(5a)** shows the right and left hands exposed side by side as is the usual practice in all such pathological conditions.

LATERAL

From the prone position the hand and forearm are half-supinated so that the palm of the hand is at an angle of 90 degrees to the film, with the fingers overlapping and the thumb directed forward and supported on a non-opaque pad.

CENTRE over the head of the second metacarpal.

(6, 7)

EXPOSURE FACTORS

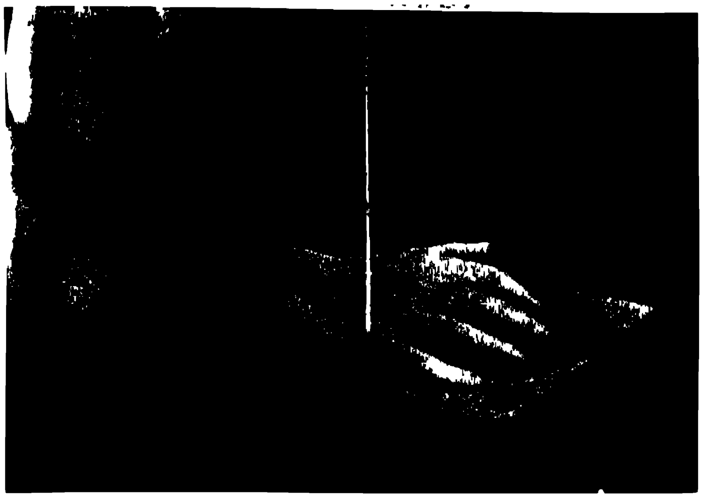
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	44	27	30″	Ilfex	–	
45	132	80	30″	Ilfex	—	
45	16	10	36″	Ilford	Tungstate	

Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in. or 10×4 in.

NOTE—In the radiograph the metacarpals overshadow and obscure each other. Nevertheless, this view is essential to show anterior or posterior displacement of fractured bones **(9)** and, in conjunction with the postero-anterior view, for locating foreign bodies **(7a)**.

SESAMOID BONES

Sesamoid bones are shown in radiographs of the hands and feet as small rounded opacities in the tendons on the palmar and plantar aspects of the joints. Examples are shown in radiographs **(17, 25, 149)** etc. They are to be seen also in other regions of the body, the patella developed in Quadriceps femoris being the largest.



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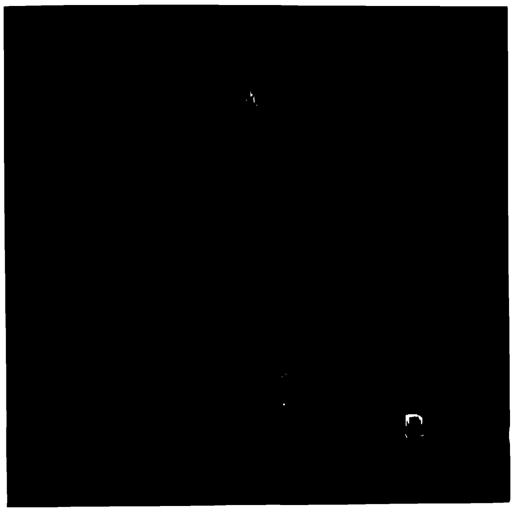

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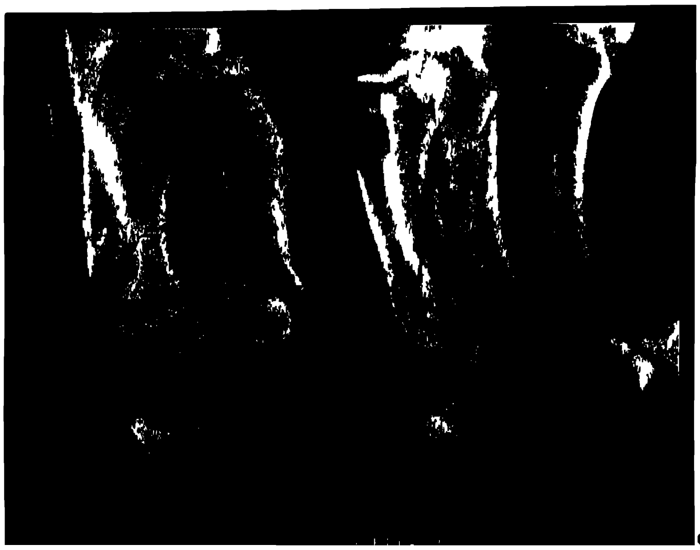
9



9a

Upper Extremity: Hand

OBLIQUE

From the lateral position the hand rotates forward to midway between the postero-anterior and the true lateral, at an angle of approximately 45 degrees to the film, the fingers being slightly flexed and separated over a non-opaque pad for immobilisation.

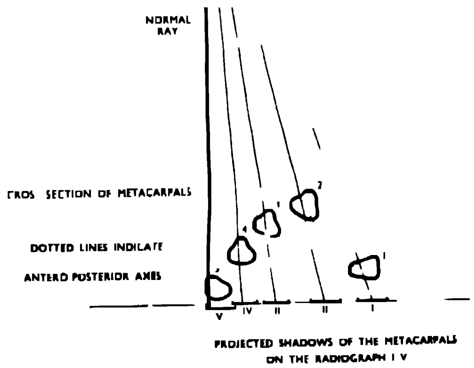
CENTRE over the upper third of the fifth metacarpal. **(8, 8a)**

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	30	18	30″	Ilfex	—	
45	90	54	30″	Ilfex		
45	11	7	36″	Ilford	Tungstate	

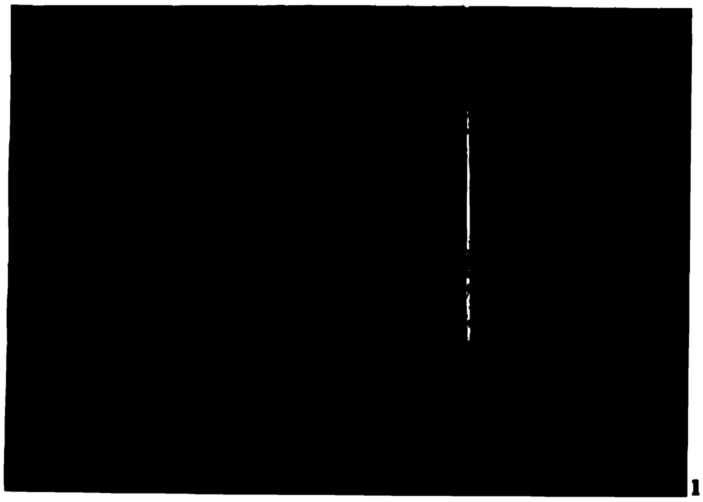
Cone to size of film, 8½ × 6½ in. or 10 × 8 in.

NOTE – This view **(8a)**, which has the advantage of separating the individual bones, is used to demonstrate minor cracks in the bones without displacement, and also to show pathological conditions. It is sometimes of value to take both lateral and oblique views of such cases, as shown in **(9, 9a)**.



10

The cross-sectional diagram shows the method of obtaining separation of the metacarpals by oblique projection **(10)**


11

Upper Extremity

Fingers

LATERAL

The hand is placed so that the whole length of the finger remains parallel to the film, and is supported when necessary by a non-opaque pad. Slightly flexing the fingers assists in obtaining a true lateral view.

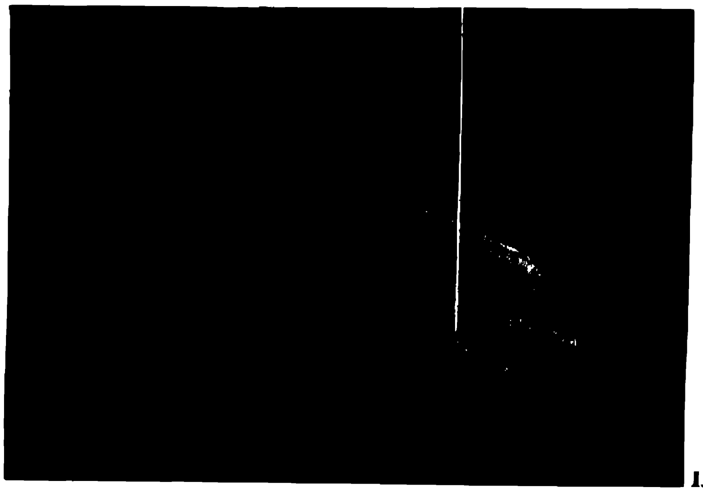

12

INDEX AND MIDDLE FINGERS

The hand is turned forward and outward until the lateral aspect of the index finger is in contact with the film, the middle finger being supported on a non-opaque pad and the remaining fingers flexed to the palm of the hand. The elbow is raised and supported on sandbags.

CENTRE over the head of the first phalanx of the index finger.

(11, 12)

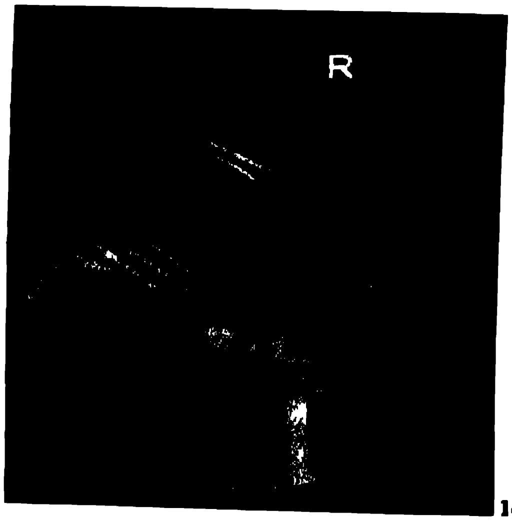

13

RING AND LITTLE FINGERS

With the hand and forearm in the true lateral position, the flexed fingers are placed with the medial aspect of the little finger in contact with the film, and with the ring finger raised on a non-opaque pad. The remaining fingers are flexed to the palm of the hand.

CENTRE over the head of the first phalanx of the little finger.

(13, 14)

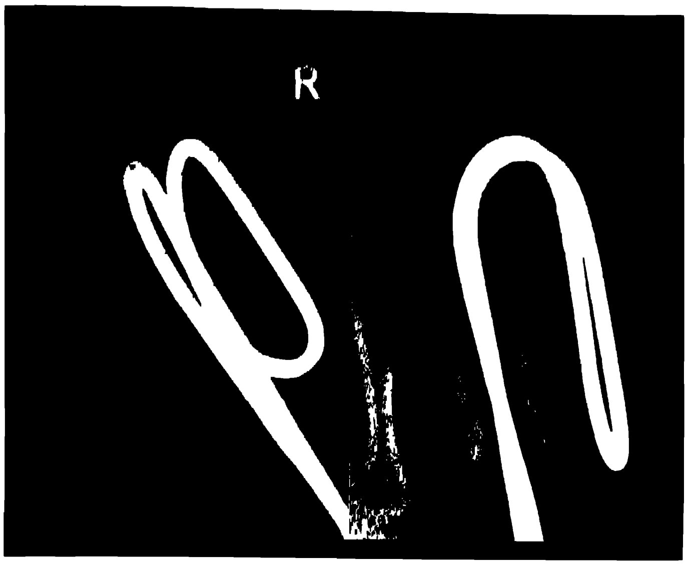


14

EXPOSURE FACTORS

kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	21	13	30″	Ilfex	—	-
45	66	40	30″	Ilfex	—	—
45	8	5	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.



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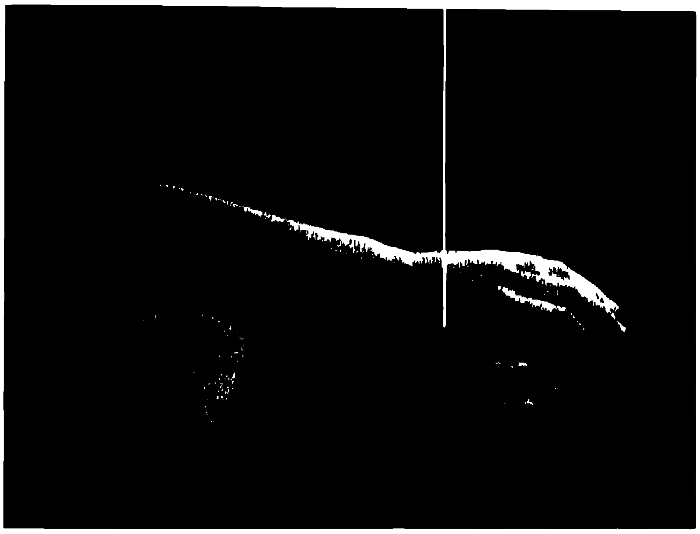

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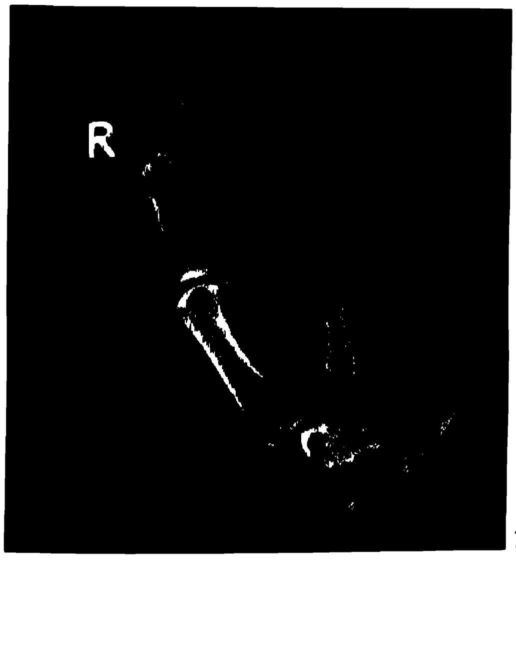


17

Upper Extremity: Thumb

FRACTURE RADIOGRAPHS

When metal splints are used, as shown in **(15)**, it is extremely difficult to obtain satisfactory postero-anterior and lateral views. It is necessary to angle both hand and X-ray tube in order to obtain sufficient separation of splint and finger to show the condition under treatment. The two views in **(15)** demonstrate the importance of angulation to avoid coincidence of the bone and splint shadows.

When an under-couch tube is available for bone radiography a preliminary screen examination will indicate the best projection.

Thumb

Unless the site of the lesion is known it is important to include the carpo-metacarpal joint in both views in order to cover the possibility of an injury, such as a Bennett's fracture, at the base of the metacarpal **(19a)**.

The choice of antero-posterior or postero-anterior view for the thumb depends largely upon the injury sustained and on the adaptability of the patient.

LATERAL

The forearm is placed in pronation and the palm of the hand raised on a non-opaque pad to bring the lateral aspect of the thumb, which is slightly flexed, in contact with the film.

CENTRE over the metacarpo-phalangeal joint.

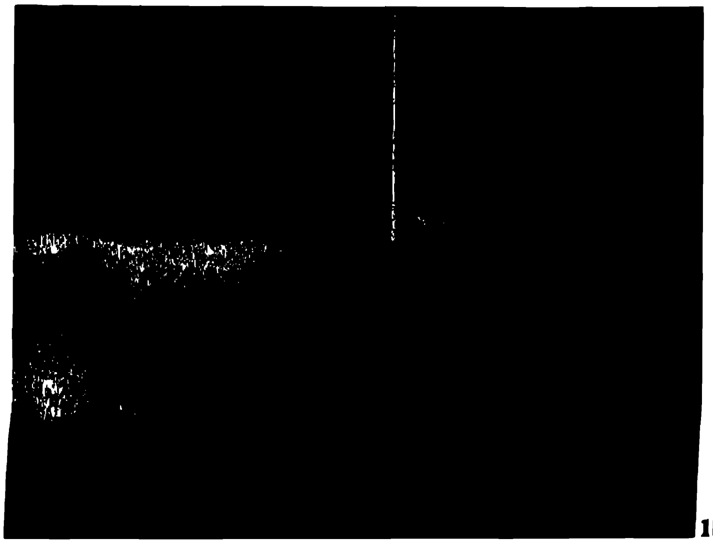
(16, 17)

EXPOSURE FACTORS

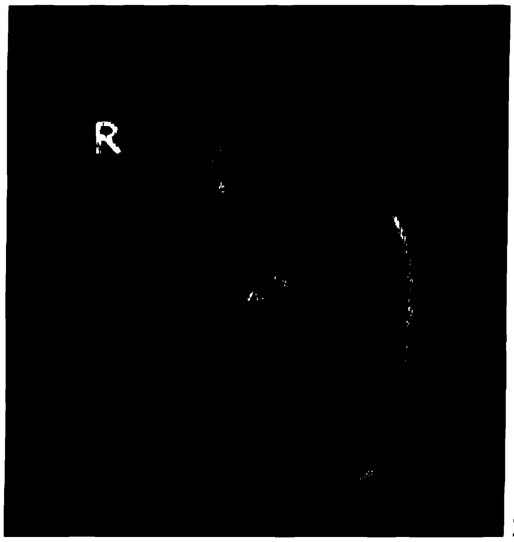
kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	21	13	30″	Ilfex		
45	66	40	30″	Ilfex		—
45	8	5	36″	Ilford	Tungstate	—

Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in.

NOTE—Two views may be taken lengthwise on the same film **(19a)**.



18



19

19a

Upper Extremity: Thumb

POSTERO-ANTERIOR

The hand is placed in the true lateral position, with the thumb separated forward and supported on a non-opaque pad. The anode-film distance is increased to 36 inches to compensate for the distortion due to the increased subject-film distance.

CENTRE over the metacarpo-phalangeal joint.

(18, 19)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	32	20	36"	Ilfex	—	—
45	95	58	36"	Ilfex	—	—
45	8	5	36"	Ilford	Tungstate	—

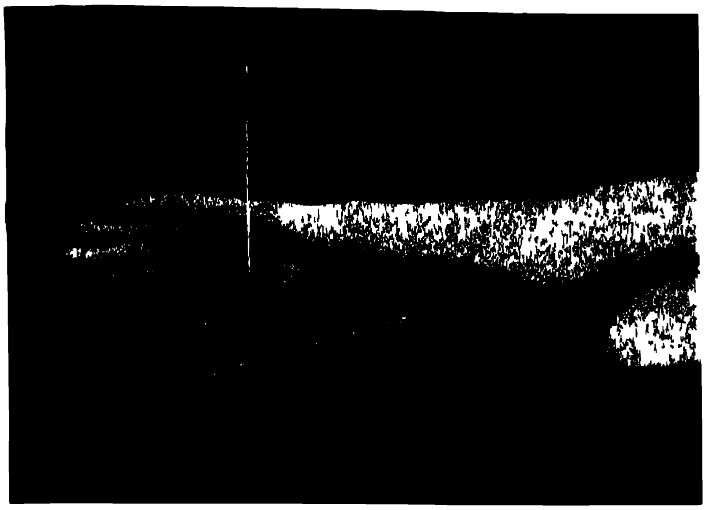
Cone to size of film, 6½ × 4¾ in.

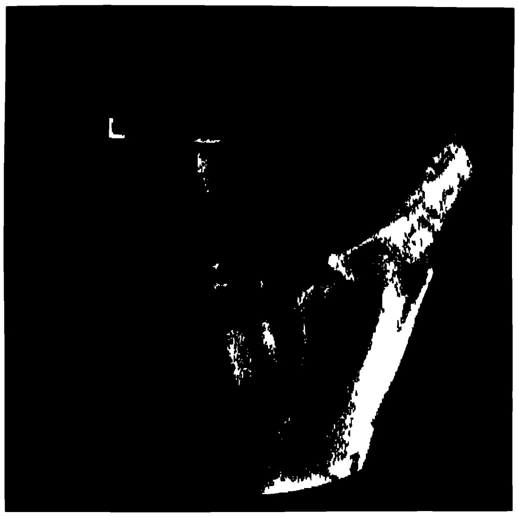
NOTE—Of the several variations quoted of this view of the thumb this is the most suitable technique to use when the thumb is badly injured and, consequently, painful.

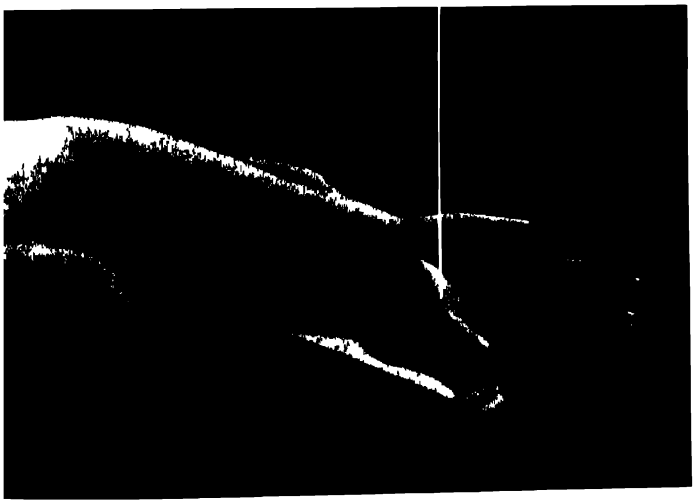
FRACTURE RADIOGRAPHS

Two views of a fractured base of thumb are shown in **(19a)**, and comparative views of the same thumb after reduction and splinting in **(19b)**. The latter may be noted as an instance of the production of satisfactory comparative views in spite of splinting which, from a radiographic point of view, presented difficulties.

19b


20


21


22


23

Upper Extremity: Thumb

ANTERO-POSTERIOR (1)

From the previous position the arm is rotated until the back of the hand approaches the couch and the posterior aspect of the thumb is in contact with the film. A cotton-wool pad is placed under the index finger and the raised elbow supported on sandbags.

CENTRE over the metacarpo-phalangeal joint.

(20, 21)

NOTE—In this position the carpo-metacarpal joint is frequently obscured. It is demonstrated in position (2) below.

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	21	13	30″	Ilfex		—
45	66	40	30″	Ilfex	—	
45	8	5	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.

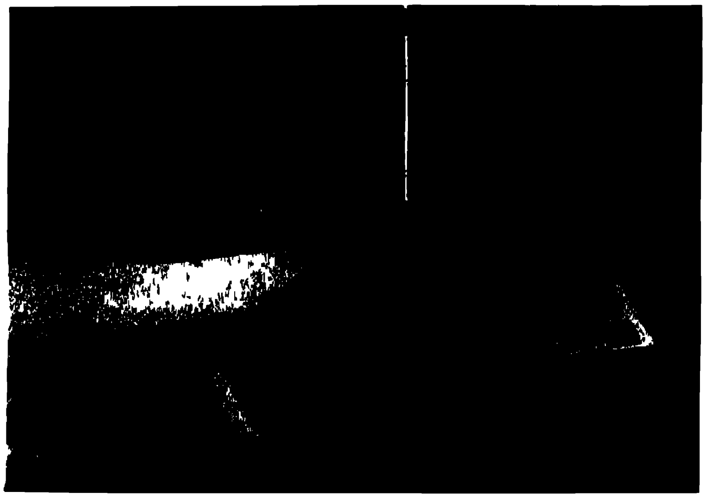
ANTERO-POSTERIOR (2)

From the antero-posterior position the hand is rotated *outward* until the posterior aspect of the thumb is in contact with the film, the fingers being supported on a cotton-wool pad.

CENTRE over the metacarpo-phalangeal joint.

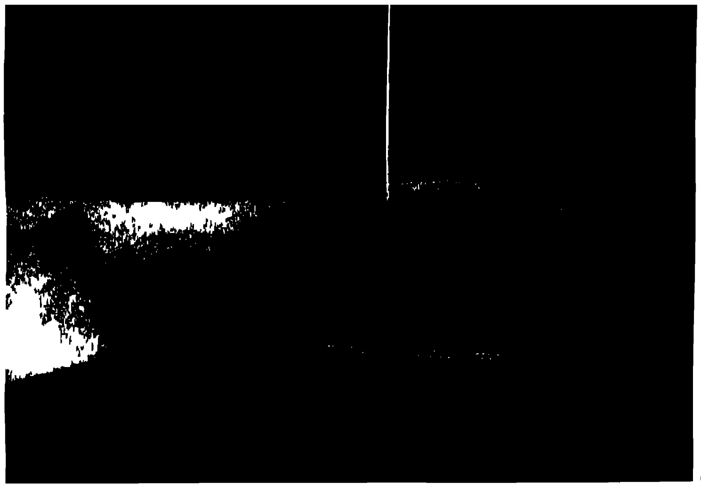
(22, 23)

NOTE—The carpo-metacarpal joint and adjacent structures are clearly shown.

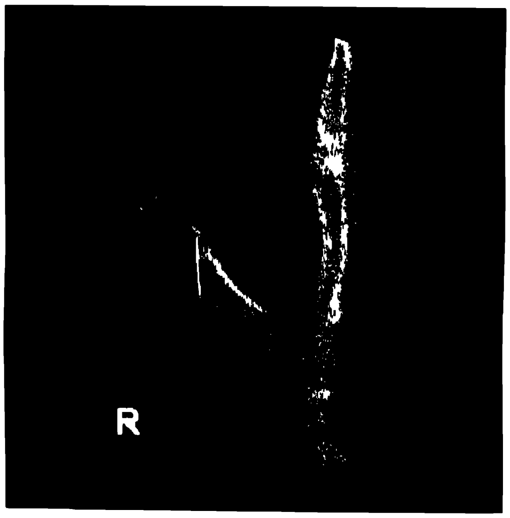


24

25



26



27

Upper Extremity: Thumb

FOREIGN BODY IN BALL OF THUMB

It is extremely difficult to show whether a foreign body, especially a needle or pin, is on the dorsal or palmar aspect of the thumb, as in the general antero-posterior and lateral positions of the hand the thumb is oblique in position, and in the special views of the thumb the true relationship with the hand is not shown. In order to demonstrate this two views are necessary.

LATERAL

The hand is tilted backward until the medial border of the thumb is parallel to the film, the hand being then almost antero-posterior in relation to the film. This position may be used as an alternative lateral view of the thumb.

CENTRE to the middle of the first metacarpal.

(24, 25)

POSTERO-ANTERIOR

The second view is taken as in the postero-anterior position of the thumb, with the hand lateral and the thumb supported on a non-opaque pad. In order to avoid any movement of the foreign body relatively to the bone, the thumb should not be allowed to move in relation to the hand between the taking of the two views.

CENTRE to the middle of the first metacarpal.

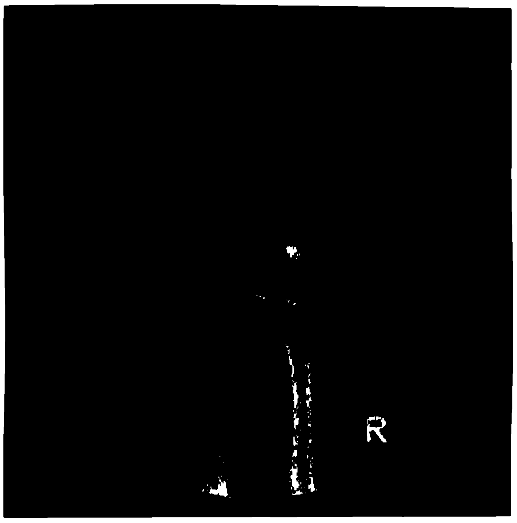
(26, 27)

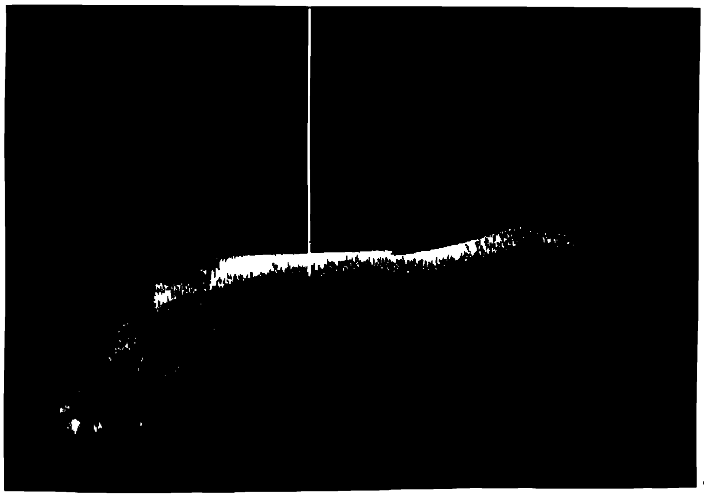
EXPOSURE FACTORS

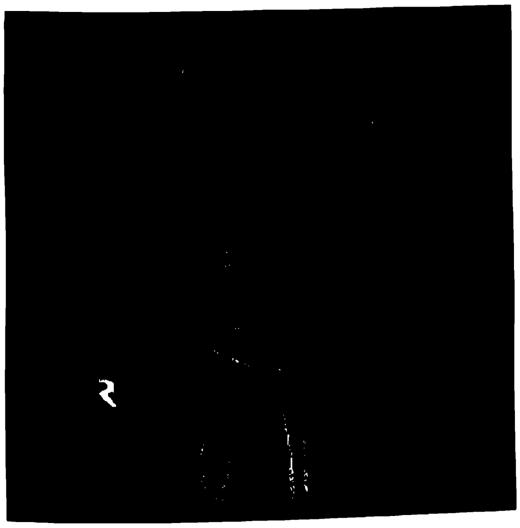
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	32	20	36″	Ilfex	—	—
45	95	58	36″	Ilfex	—	—
45	8	5	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.


28


29


30


31

Upper Extremity

Wrist Joint

Radiographs of the wrist joint include the distal extremities of the radius and ulna, the carpal bones and the bases of the metacarpals. X-ray examination is most frequently carried out following the clinical diagnosis of Colles's fracture. In these cases it is of value to include the maximum area of radius and ulna on the film in preference to the upper thirds of the metacarpals, so that in using a small film it is advisable to place the centre of the film one inch below the tube centring point.

POSTERO-ANTERIOR

The forearm is placed on the couch, with the elbow flexed and the hand pronated, i.e., palm to couch.

The wrist and hand should be relaxed. A small cotton-wool pad under the metacarpo-phalangeal joints, similar in effect to the raised end of a Carr's splint, assists relaxation. Any forced extension raises the wrist from the film and is therefore to be discouraged.

CENTRE midway between the radial and ulnar styloid processes.

(28, 29)

POSTERO-ANTERIOR WITH ULNAR DEVIATION

The forearm is placed in the same position as for the previous view, with the hand adducted toward the ulnar side.

CENTRE midway between the radial and ulnar styloid processes.

(30, 31)

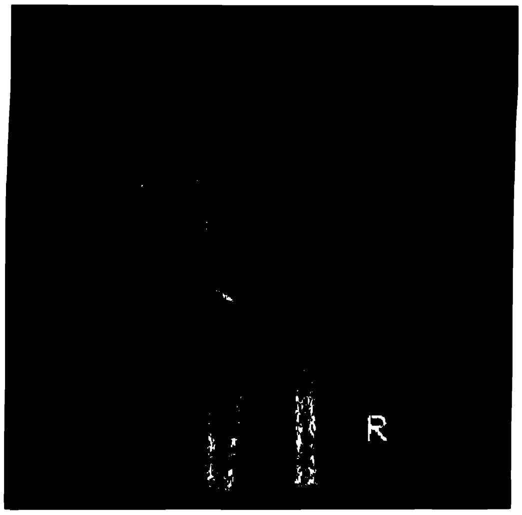
NOTE—In this position there is good separation of the carpal bones, especially the navicular. It is not always possible to apply ulnar adduction to the injured subject, in which case the previous position is used.

EXPOSURE FACTORS

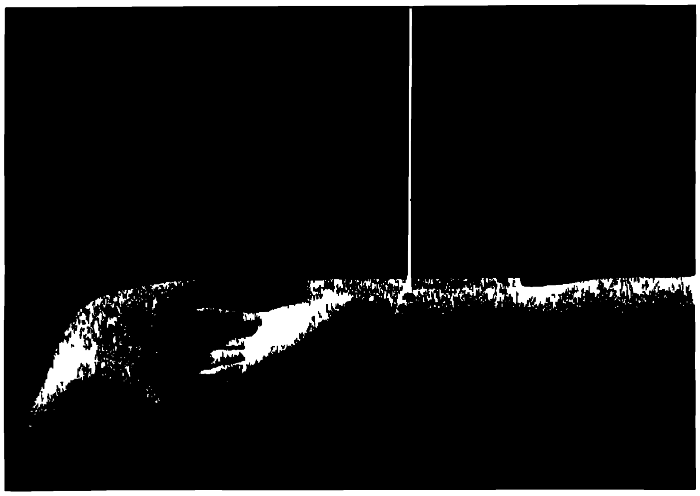
kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Blue Label	Distance	Film	Screens Ilford	Grid
60	30	18	30″	Ilfex	—	—
50	60	36	30″	Ilfex	—	—
45	10	6	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.

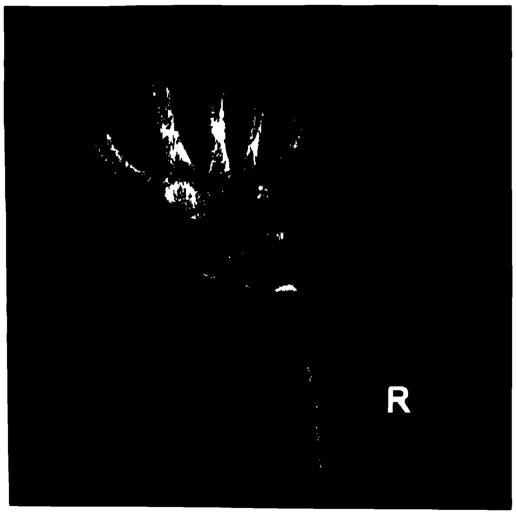
32



33



34



35

Upper Extremity: Wrist Joint

POSTERO-ANTERIOR WITH TUBE ANGLED

The wrist is in the same position as for (28), the tube being angled 30 degrees toward the forearm.

CENTRE in the mid-line, between the radial and ulnar styloid processes.

(32, 33)

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	30	18	30″	Ilfex		
50	60	36	30″	Ilfex		
45	10	6	36″	Ilford	Tungstate	

Cone to size of film, 6½ × 4¾ in.

NOTE—This view shows a clear joint space between the radius and carpal bones, but the carpo-metacarpal joints are somewhat distorted.

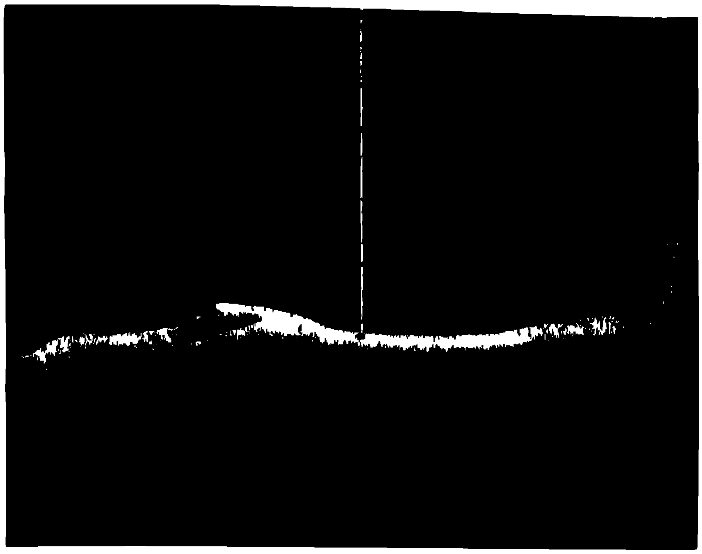
ANTERO-POSTERIOR

The arm is placed in full supination, with extension of the elbow joint. This position may be used with or without ulnar deviation. The same result is obtained with the forearm in pronation, using the under-couch tube.

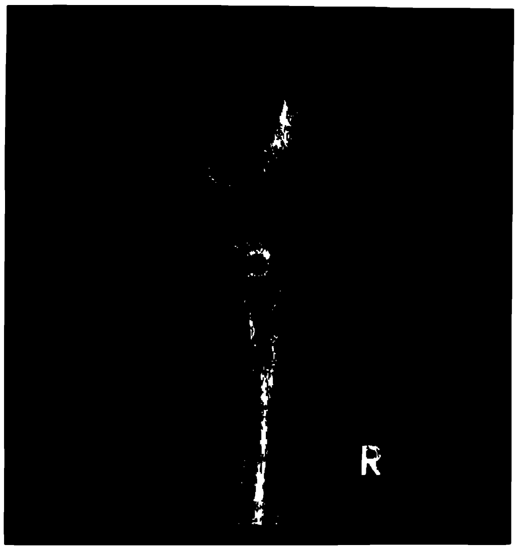
CENTRE midway between the radial and ulnar styloid processes.

(34, 35)

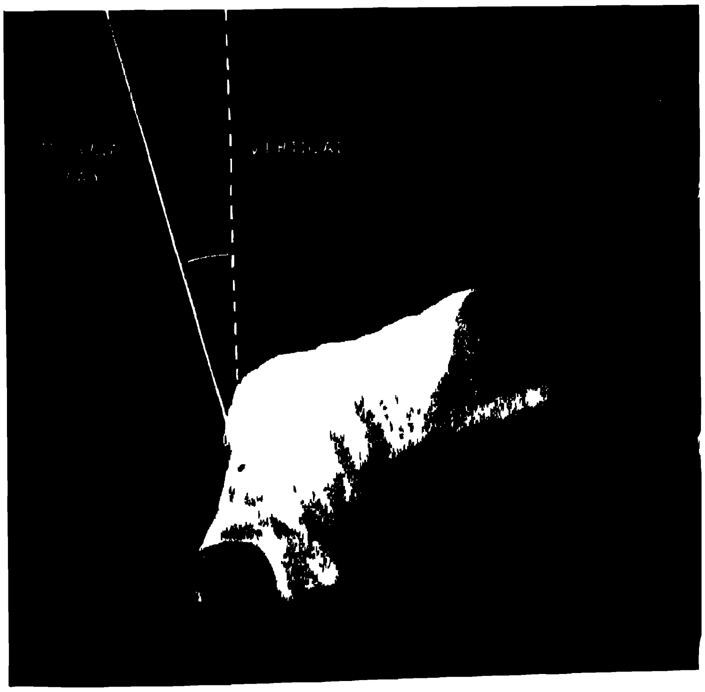
NOTE—As the inter-articulations of the carpal bones converge from the posterior to the anterior aspect, clearer joint spaces are shown in the antero-posterior position. This, however, is offset by the fact that it is usually a painful adjustment for the injured subject, while for the alternative, prone position of the wrist the under-couch tube is not always available; hence the generally applied postero-anterior technique with the tube overhead.



36



37



38

Upper Extremity: Wrist Joint

LATERAL

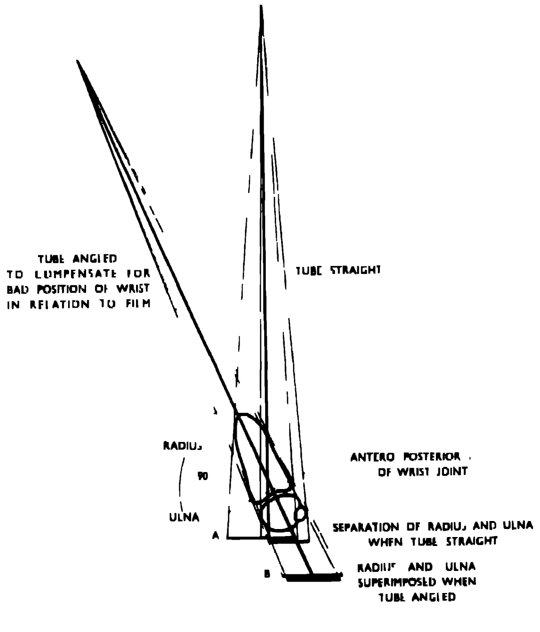
With the forearm lateral so that the palm of the hand is facing the trunk, an additional backward tilt is given to the wrist to superimpose the radius on the ulna, the wrist being sandbagged in position, with support for the thumb.

CENTRE to the radial styloid process.

(36, 37)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	55	34	30″	Ilfex	—	—
50	110	67	30″	Ilfex	—	—
45	18	11	36″	Ilford	Tungstate	—

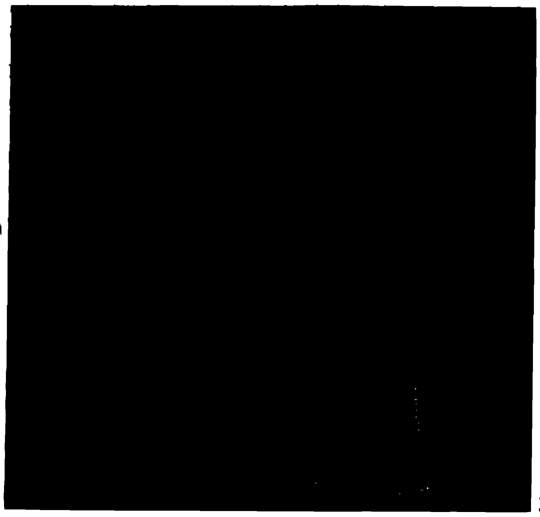
Cone to size of film, 6½ × 4¾ in.



38a

NOTE—In fracture cases true antero-posterior and lateral views are essential for comparison throughout manipulation and healing. When the wrist cannot be placed in the true positions, owing to pain or the presence of splint or plaster, the tube may be angled to compensate for any rotation of the wrist, as shown in **(38)**. Radiographs illustrating this point are shown on page 22.

The cross-sectional diagram shows the method of obtaining a true lateral view of the wrist joint by tube angulation **(38a)**.


39


40


41

42

Upper Extremity: Wrist Joint

FRACTURE RADIOGRAPHS (COLLES'S)

These radiographs of an injured wrist, exposed twice from postero-anterior and lateral aspects, indicate the possible variations due to positioning, which could be very misleading to the surgeon manipulating the fragments, and stress the importance of taking *true* antero-posterior and lateral views. In each pair of radiographs the correct position is that shown on the right.

(39, 40)

DISLOCATIONS

When dislocation of one or more carpal bones is suspected, true lateral views of both wrists should be taken for comparison, preferably both being shown on the same film.

CENTRE between the wrists, at the level of the styloid processes.

(41, 42)

EXPOSURE FACTORS

kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	55	34	30″	Ilfex	—	—
50	110	67	30″	Ilfex	—	—
45	18	11	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.

NOTE—In positioning the arms the additional backward rotation of the wrist as described previously is not necessary, as with the tube centred between the wrists the oblique rays give a true lateral projection.

FRACTURE RADIOGRAPHS (NAVICULAR)

From the six radiographs of the wrist (45), taken to show a fracture of the navicular bone, a selection may be made of the most satisfactory views of *this particular subject*. It should be borne in mind, however, that other positions may prove to be more successful in particular cases of this type of injury.

The most satisfactory demonstration of the fracture is seen in view (b)—postero-anterior with ulnar deviation. It is shown less clearly in postero-anterior view (a), and is difficult to distinguish in both antero-posterior view (c) and lateral view (d); it is distinguishable in oblique view (e), and is more clearly seen in *modified* oblique view (f).

(45)

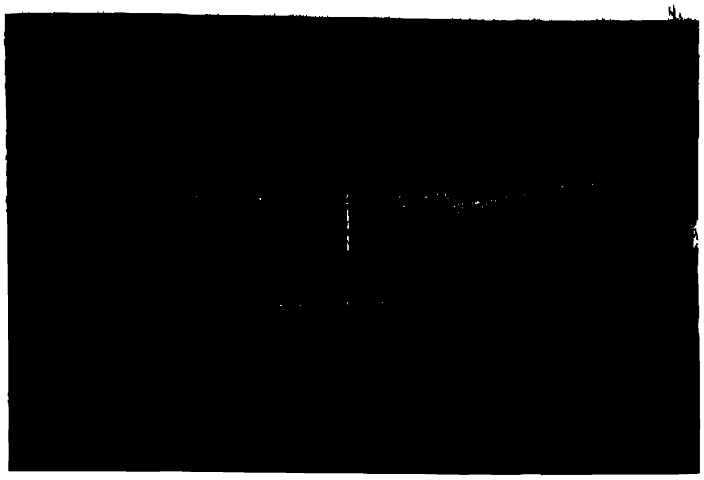
Upper Extremity: Wrist Joint

OBLIQUE

From the lateral position the wrist is rotated forward to a position midway between the postero-anterior and the true lateral as for the oblique view of the hand, a non-opaque pad being placed under the radial aspect of the hand and wrist.

CENTRE over the ulnar styloid process.

(43, 43a)



43

43a

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	36	22	30″	Ilfex	—	—
50	72	43	30″	Ilfex	—	—
45	13	8	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in.

NOTE - This gives a useful third view of the carpal bones, especially the navicular, and may demonstrate a minor fracture which is obscured in other views. For comparison both wrists may be taken on the same film, but separate exposures are necessary to ensure correct centring.

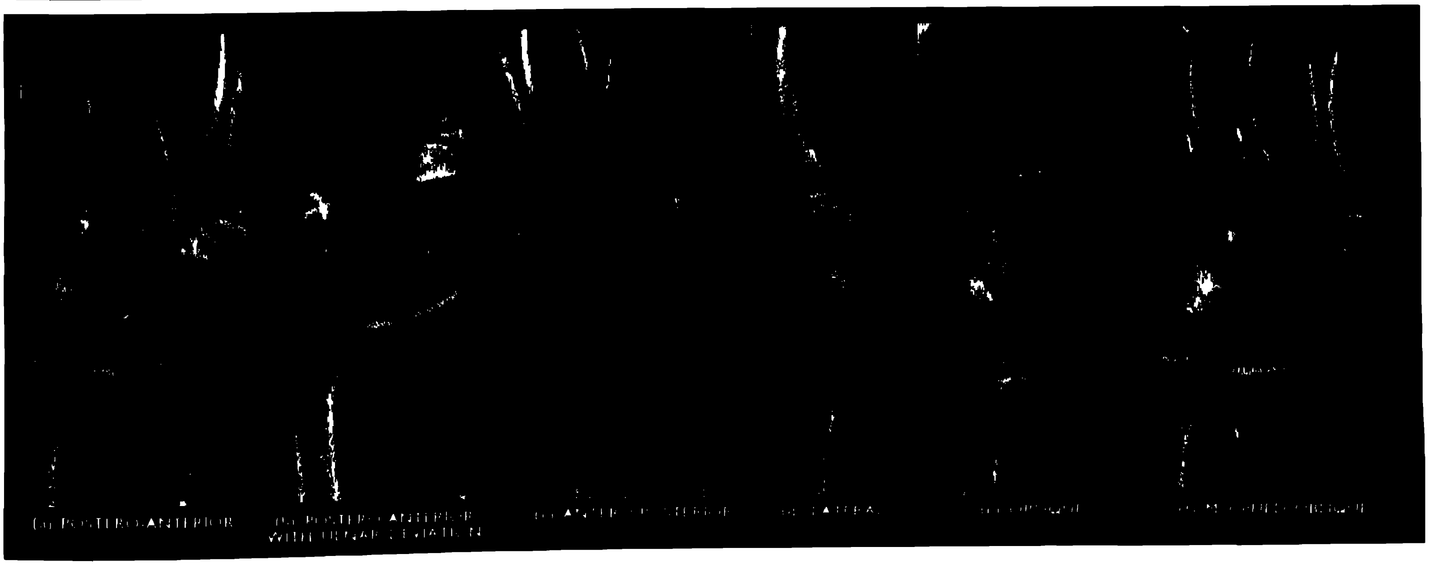
OBLIQUE, WITH ULNAR DEVIATION

Both wrists are exposed on the same film, in the oblique position, with thumbs in contact and hands adducted toward the ulnar side.

CENTRE between the wrists, at the level of the ulnar styloid process. (44)

NOTE—This is a somewhat unusual projection.

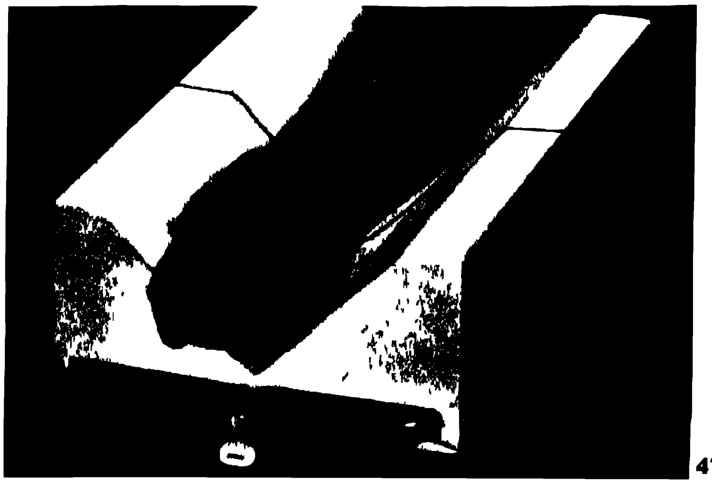
44



45

46

46a



47

47a

Upper Extremity: Wrist Joint

NAVICULAR

A second oblique view of the wrist joint with the hand *supine* enables the navicular bone to be shown through its *major* axis **(47a)** for comparison with the standard oblique view taken with the hand *prone*, when the navicular is shown through its *minor* axis **(46a)**. Thus, regarding the navicular bone as apart from the wrist, true postero-anterior and lateral views are obtained which enable the surgeon to estimate the direction of insertion of a pin into fracture fragments.

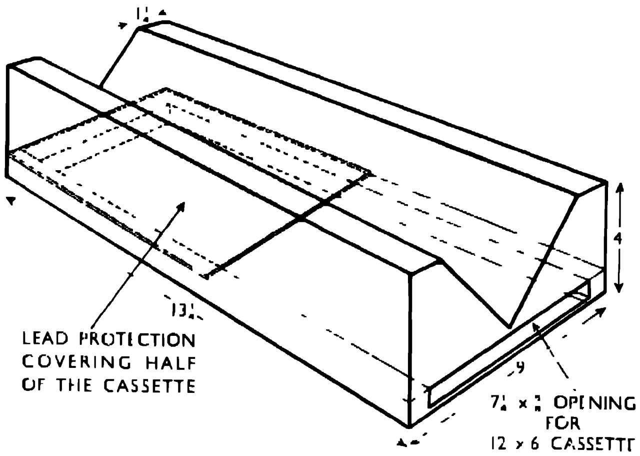
A special angle support is used for the taking of the radiographs and for the pinning operation. This support, a diagram of which is shown at **(46b)**, takes the form of a right-angled trough with the sides inclined at an angle of 45 degrees to the horizontal and having a slot for the film cassette immediately below. One half of the length of the trough is backed with lead foil. A 12 by 6 inches film is used.

The arm is placed in turn in the normal oblique postero-anterior **(46, 46a)**, and oblique antero-posterior **(47, 47a)** positions and exposures made, the cassette being reversed in the slot, *between* exposures, to give each section in turn the protection of the lead backing.

Owing to the angle at which the trough supports the limb, the first exposure gives a *true* postero-anterior view of the navicular and the second a true lateral.

CENTRE to the angle of the trough.

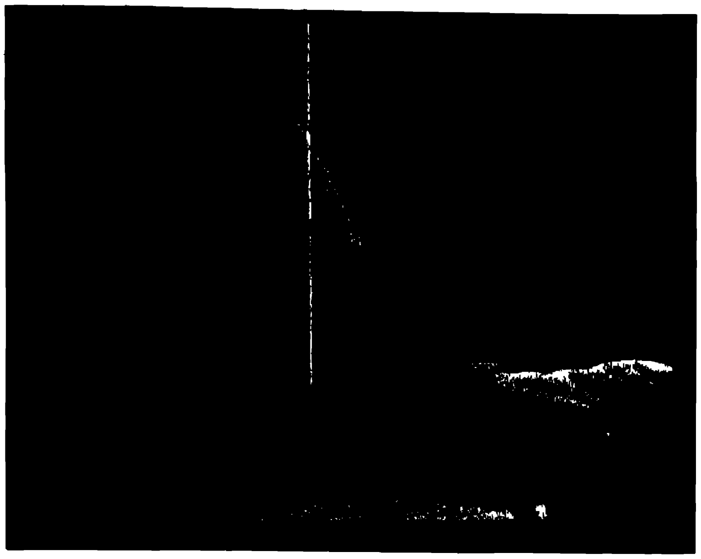
(46, 46a, 46b, 47, 47a)



46b

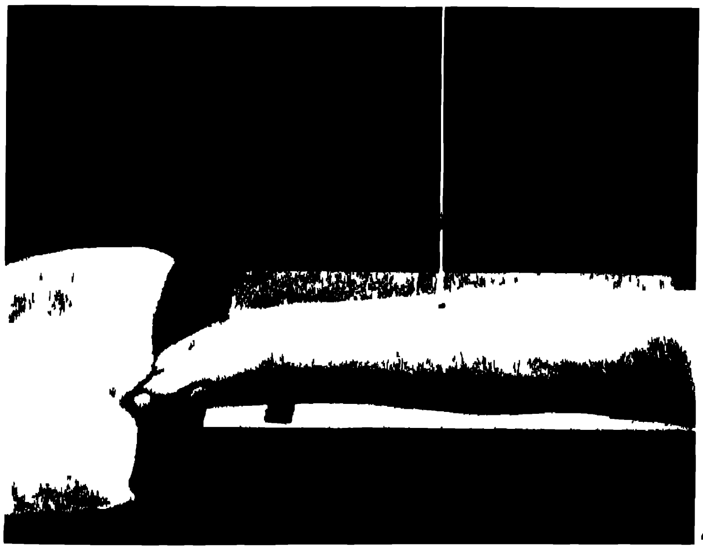
Dimensions of the angle support are shown in line diagram **(46b)**.

NOTE—The second oblique **(47a)** gives also a satisfactory projection of the pisiform bone, showing its antero-posterior relationship with the cuneiform bone (triquetral).



48

48a



49

49a

Upper Extremity

Forearm

A common error in radiographing the forearm is to follow wrist joint positioning, the wrist being rotated between pronation and half-supination for postero-anterior and lateral views, respectively, and *the elbow joint remaining flexed.* While this positioning gives satisfactory results as far as the wrist joint is concerned, it should not be forgotten that there is no relative movement of radius and ulna *unless the arm is fully extended* between lateral and antero-posterior positions. It is therefore essential to use the positions shown in (1, 2) on page 10.

LATERAL

The limb is arranged in position with the elbow flexed and the forearm half-supinated, the hand being sand-bagged in position, with support for the thumb.

(48, 48a)

ANTERO-POSTERIOR

From the lateral position the limb is raised by firmly holding the upper arm and forearm, the arm being rotated, from the shoulder joint, to full supination. The elbow joint is extended and the shoulder kept well down to the level of the couch.

CENTRE to the middle of the forearm.

(49, 49a)

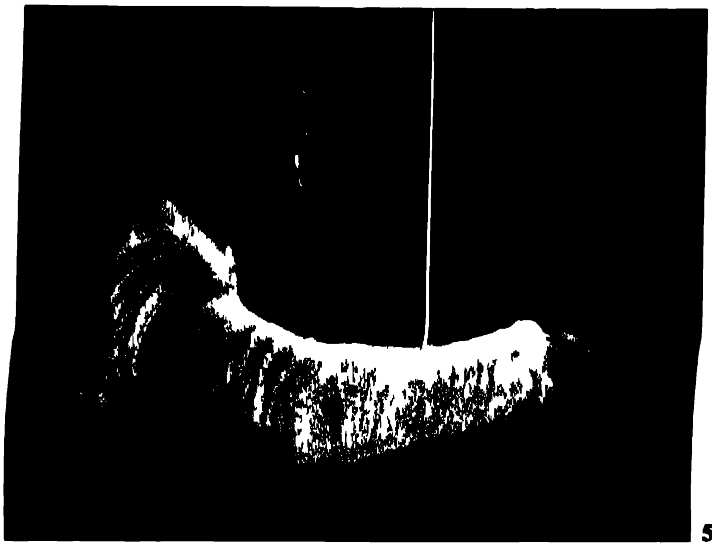
The exposure factors should be adjusted to wrist or elbow joint technique according to the region involved. When the whole forearm is to be included the following exposure factors apply, the exposure time being increased by one-third for the lateral view.

NOTE—Films should include the wrist and elbow, unless only one joint is required, the joint nearest the injury being *always* included.

EXPOSURE FACTORS

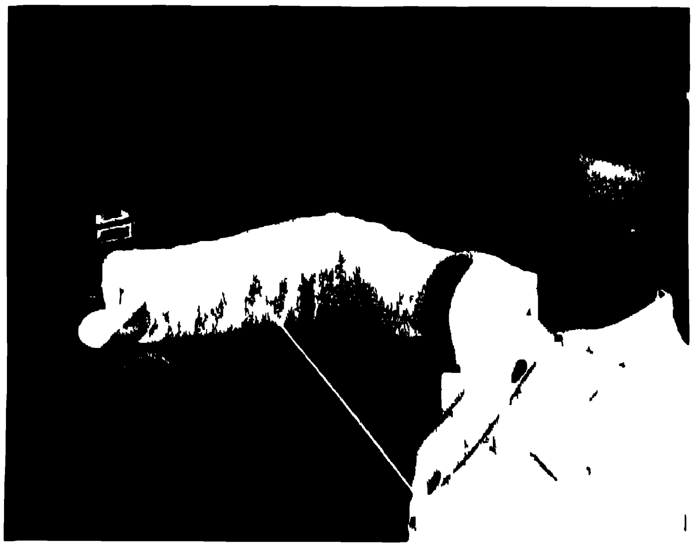
kVp	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	40	24	30"	Ilfex		–
50	80	48	30"	Ilfex	—	—
50	10	6	36"	Ilford	Tungstate	—

Film 10 × 4 in., 12 × 6 in. or 15 × 6 in.



50

51



52

53

Upper Extremity: Forearm

INJURIES

A splint or plaster fixing the elbow and wrist joint may complicate the previous positions. In these cases, after taking the arm in the prone position **(50)**, and without moving the patient, the film is placed vertically on the posterior aspect of the forearm, and, using the ward *trolley unit, the X-ray beam is projected horizontally from* the anterior aspect **(52)**

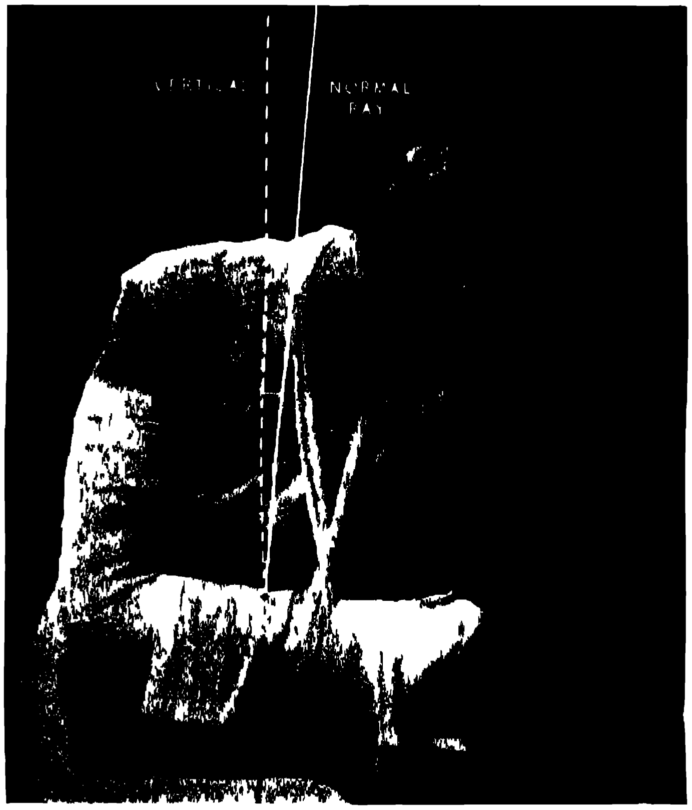
CENTRE to the middle of the forearm

(50, 51, 52, 53)

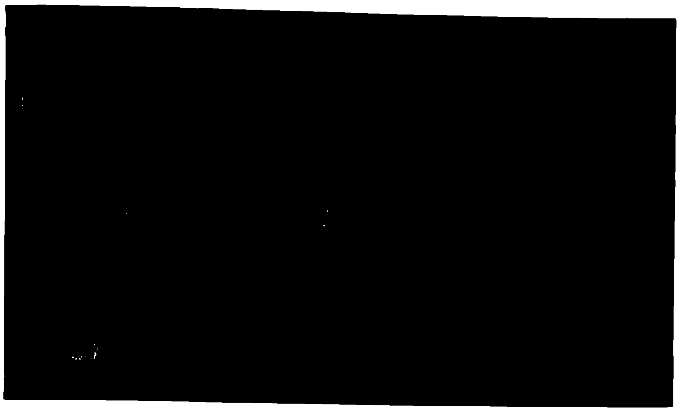
NOTE—It is most important to use a film large enough to include a considerable length of bone on each side of the injury in order to show the general alignment of the fragments This is especially important in greenstick fractures in children, when the whole length of the bone should be included.

In fracture cases it is sometimes impossible to place the arm on the table Views are then obtained by bandaging the films to the arm and projecting the beam horizontally for the postero-anterior view, and from above the shoulder for the lateral view By this method two useful views at right angles to each other are secured

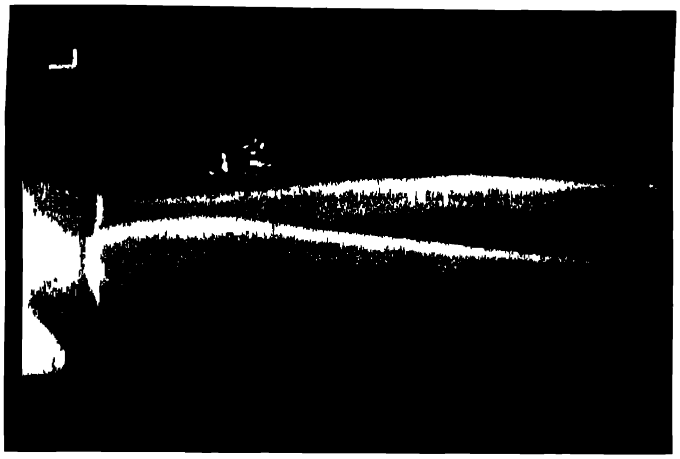
(54)



54

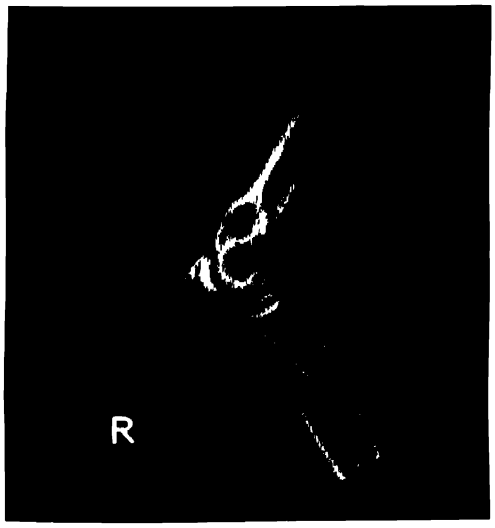


55



56

57



58

Upper Extremity: Elbow Joint

FOREIGN BODIES IN FOREARM

When examining the forearm for the presence of foreign bodies it is most important that both views be taken *without moving the limb.* The forearm should be placed with the palm of the hand in contact with the couch and the elbow flexed, as shown in **(59)**.

After exposing from this aspect, and obtaining the result shown in **(55)**, the second film is placed against the outer aspect of the forearm and at right angles to the couch, the X-ray beam being projected horizontally, as shown in **(52)**. The radiographic result is seen in **(56)**.

Elbow Joint

The most satisfactory views of the elbow joint are obtained when the upper arm is on the same plane as the forearm, the more easily adjusted lateral being taken before the antero-posterior view in order to gain the patient's confidence.

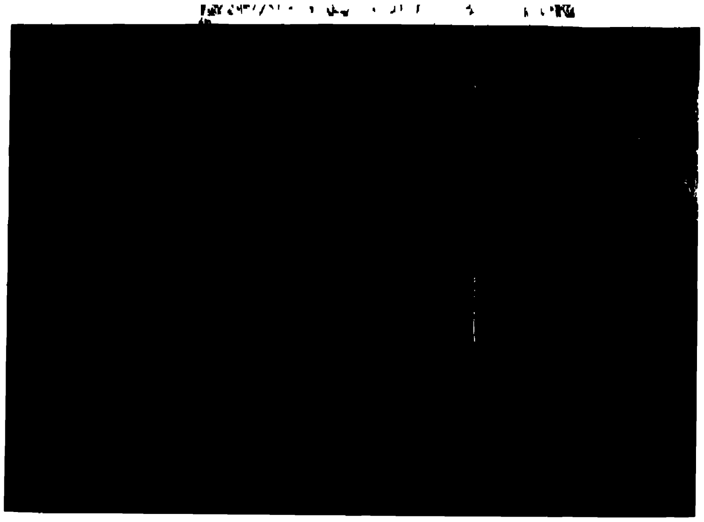
LATERAL (1)

The arm and forearm are in the true lateral position with the elbow joint flexed at an angle of approximately 90 degrees. The hand and the upper arm are sandbagged in position.

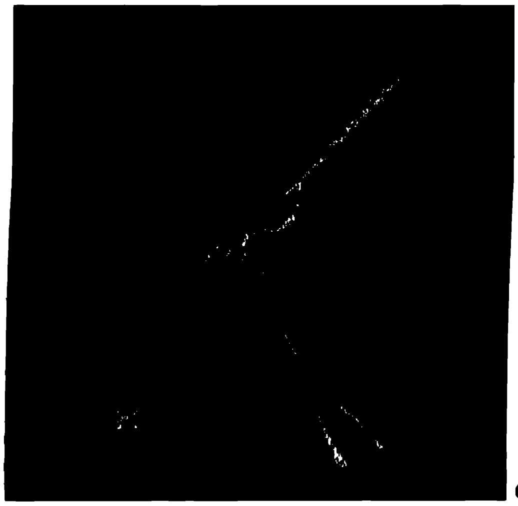
CENTRE to the lateral condyle of the humerus.

(57, 58)

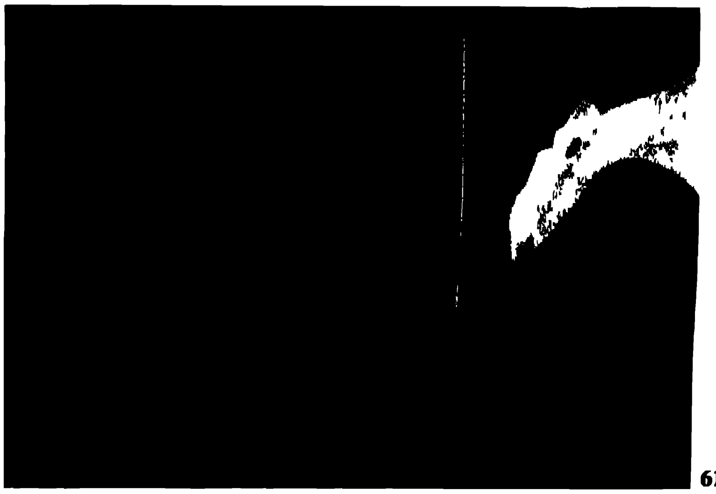
NOTE—This position gives a true lateral view of all bones entering into the elbow joint.



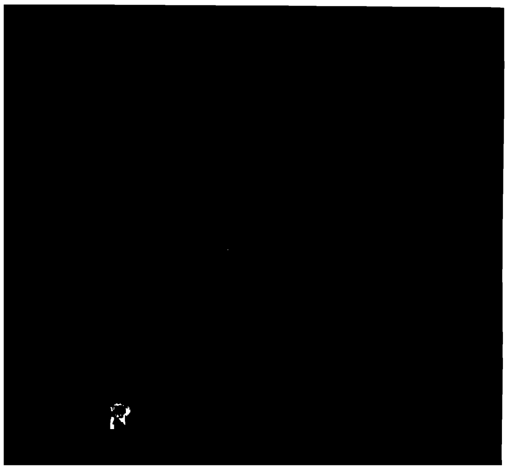
59



60



61



62

Upper Extremity: Elbow Joint

LATERAL (2)

From the previous position the hand is allowed to rotate forward until the palm is in contact with the couch.

CENTRE over the lateral condyle of the humerus.

(59, 60)

NOTE—Although there is a diversity of opinion as to which is the more satisfactory of these two positions, **(57)** or **(59)**, while the former gives a true lateral view of the radius, it is usually easier for the patient to adopt and maintain the latter position.

LATERAL (3)

With the elbow flexed, the hand rotates forward until the radial aspect is in contact with the couch and the palm of the hand faces away from the trunk.

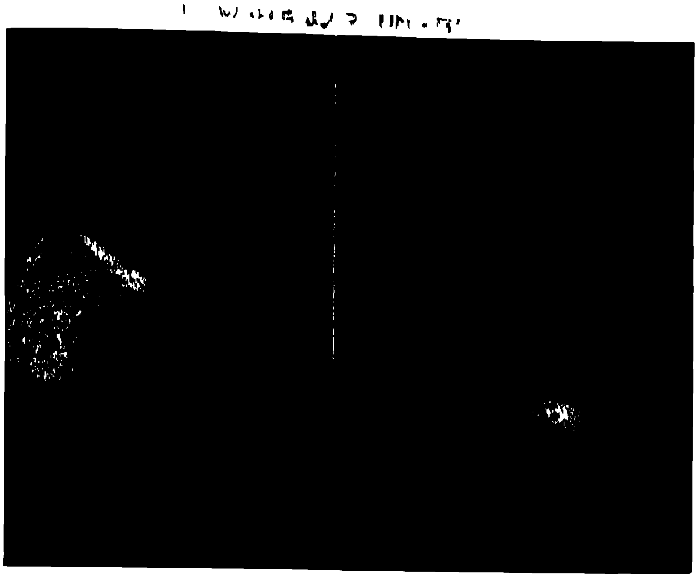
(61, 62)

NOTE—This third position is included to show still further variation in the appearance of the head of the radius. In each position the only movement at the elbow joint is the rotation of the radial head. When it is possible to take it, an additional lateral view may assist in the matter of a negative diagnosis when the question of a minor injury to the head of the radius is involved.

Lateral (1), (2), (3) EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Ilfex	—	—
50	100	60	30″	Ilfex	—	—
50	12	7	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.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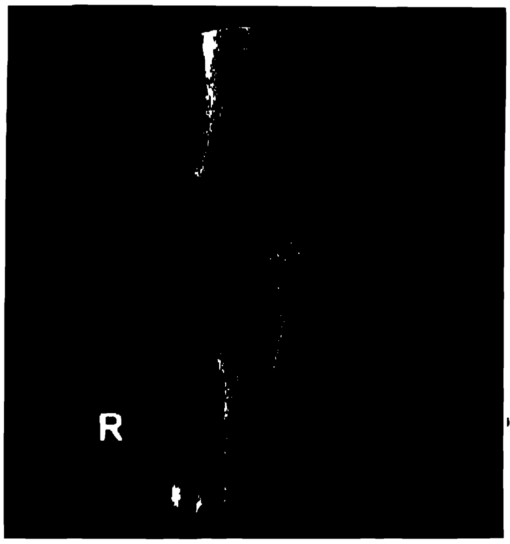
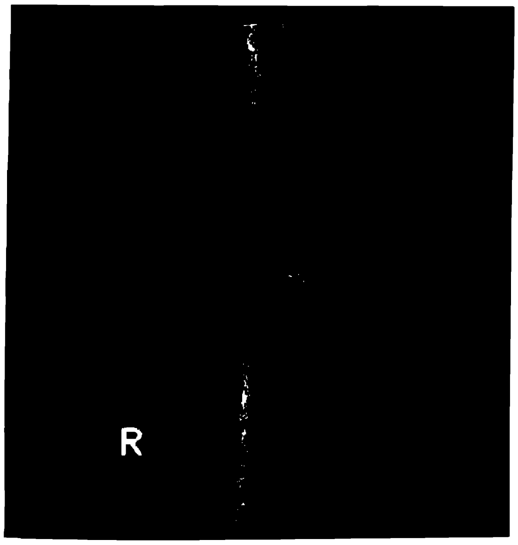


64



65

Upper Extremity: Elbow Joint

ANTERO-POSTERIOR (1)

From the lateral position the arm is gently but firmly grasped above and below the elbow joint and rotated outward from the shoulder joint, the elbow being gently extended over the couch until the arm is fully supinated and facing the tube, with the shoulder well down so that the arm and forearm are in one plane and the elbow joint is in the true antero-posterior position.

CENTRE one inch below the mid-point between the condyles.

(63, 64)

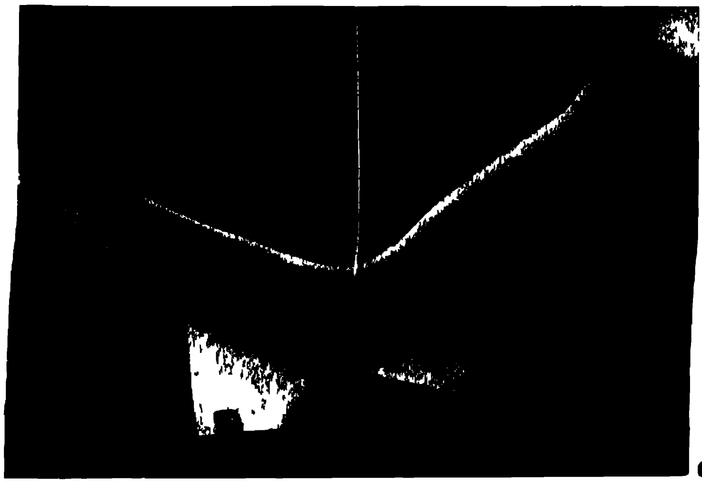
EXPOSURE FACTORS						
	mA Secs.					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Ilfex	—	—
50	100	60	30″	Ilfex	—	—
50	12	7	36	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in or 8½ × 6½ in

The nearest approach to this view **(64)**, when the elbow cannot be extended on account of injury, is shown on page 31 in position **(70)** resulting in radiograph **(71)**. The necessary increase of 5 kilovolts in the exposure factors should be noted

NOTE—A second radiograph shows the effect of allowing the hand to rotate into the prone position so that the shaft of the radius crosses that of the ulna.

(65)



66

Upper Extremity: Elbow Joint

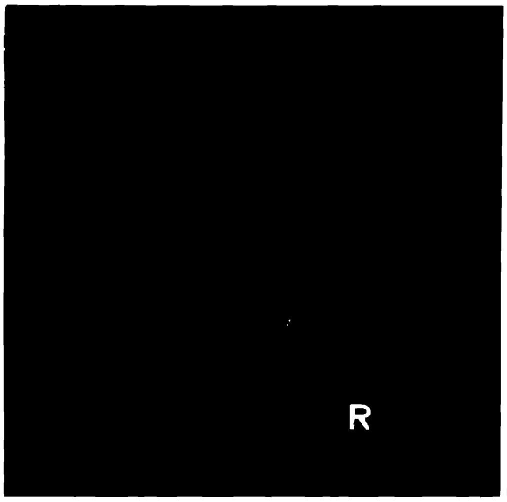
ANTERO-POSTERIOR (2)

When the joint cannot be fully extended sandbags are placed under the arm and forearm to support the elbow in the flexed position, avoiding pressure on the olecranon process. The angles between limb and film above and below the joint are equalised.

CENTRE to the angle of the elbow.

(66, 67)

NOTE—This position gives a satisfactory general view of the joint, with equal distortion of upper and lower aspects



67

68

ANTERO-POSTERIOR (3)

When there is flexion of the joint due to a known injury of the humerus, it is best demonstrated with the arm in contact with the film and with the forearm supported.

CENTRE midway between the condyles.

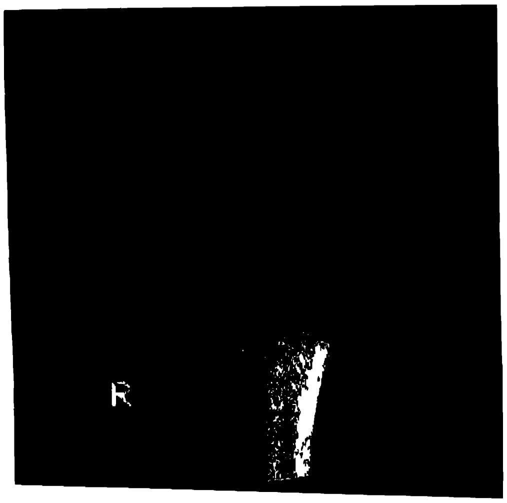
(68, 69)

NOTE—This position is usefully applied to give additional evidence in cases of epiphysial injury of the humerus.

EXPOSURE FACTORS

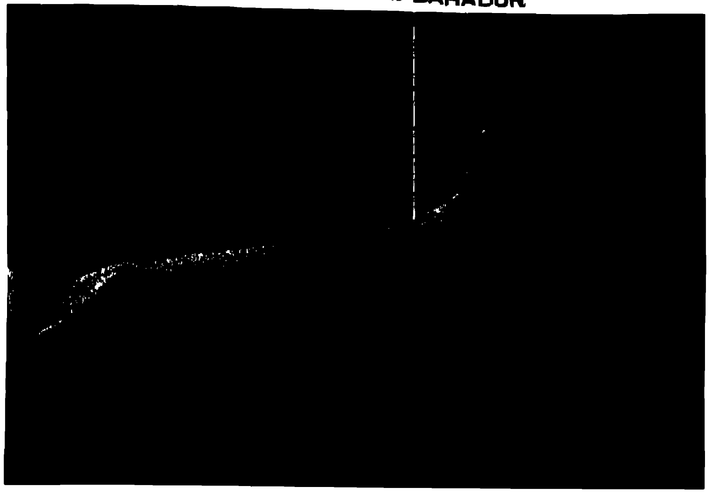
kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	50	30	30″	Ilfex	—	—
55	100	60	30″	Ilfex	—	—
55	12	7	36″	Ilford	Tungstate	—

Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in. or $8\frac{1}{2} \times 6\frac{1}{2}$ in.

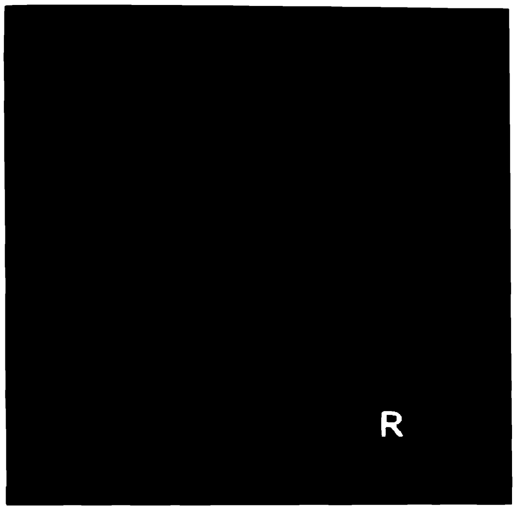


69

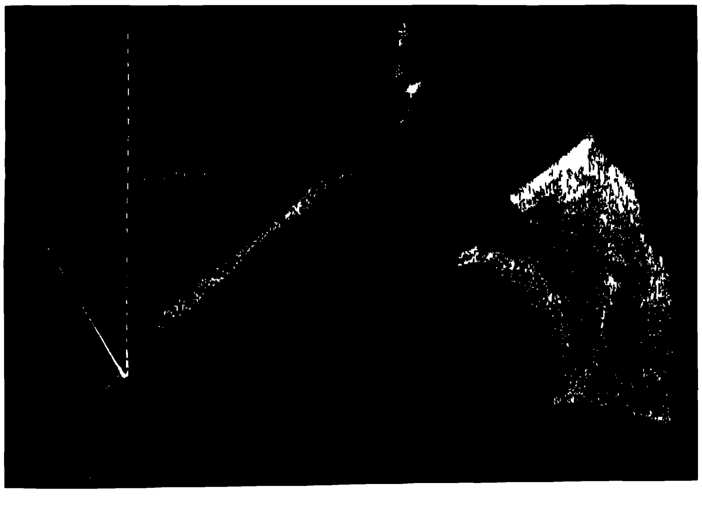
NAWAB SALAR JUNG BAHADUR



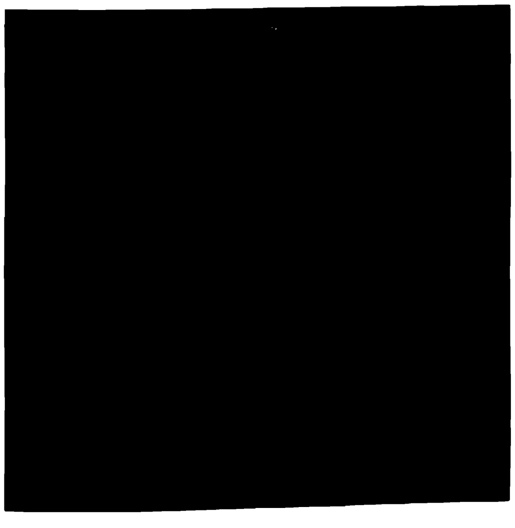
70



71



72



73

Upper Extremity: Elbow Joint

ANTERO-POSTERIOR (4)

Similarly, when the injury is to the radius and ulna, with flexion, the forearm is placed in contact with the film and the humerus supported on sandbags.

CENTRE one inch below the mid-point between the condyles.

(70, 71)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	50	30	30″	Ilfex	—	—
55	100	60	30″	Ilfex	—	—
55	12	7	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.

NOTE—This position gives the nearest approach to the results obtained in the normal subject with the elbow fully extended (64).

ANTERO-POSTERIOR (5)

When there is extreme flexion, with the hand in contact with the shoulder, the beam is directed through both forearm and arm.

CENTRE two inches distal from the olecranon process, with the tube angled 30 degrees toward the shoulder.

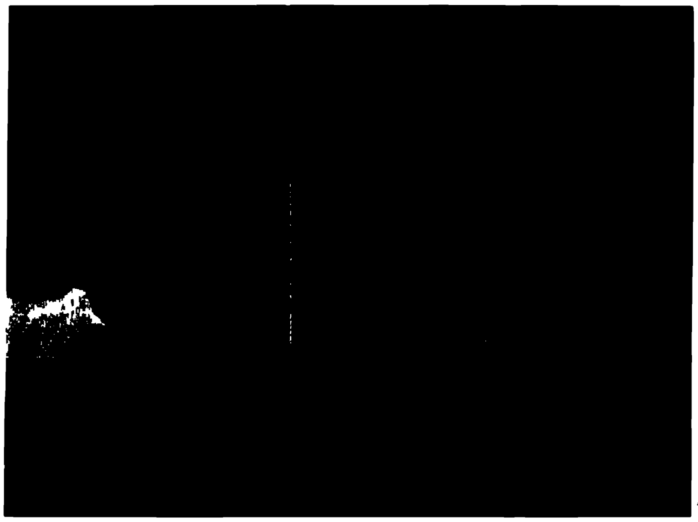
(72, 73)

NOTE—This view shows the bones of the forearm superimposed upon the humerus, and gives the general alignment of the bones in gross injury.

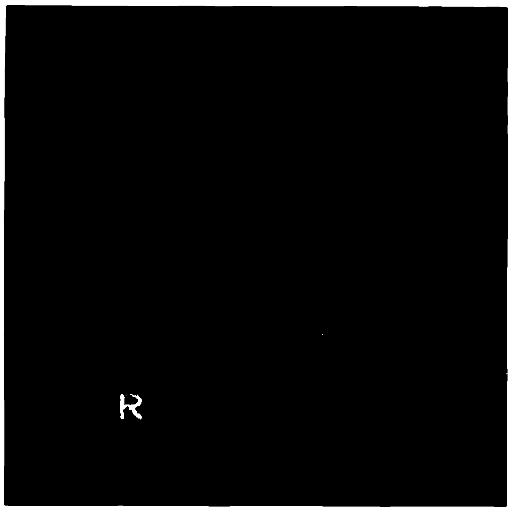
Increase by 10 kilovolts on the antero-posterior exposure.

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	50	30	30″	Ilfex	—	—
65	100	60	30″	Ilfex	—	—
65	12	7	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.



74



75

Upper Extremity: Elbow Joint

PROXIMAL RADIO-ULNAR ARTICULATION ANTERO-POSTERIOR

From the normal antero-posterior position the arm is rotated slightly outward.

CENTRE over the humero-radial articulation.
(74, 75)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Illex	–	—
50	100	60	30″	Ilfex		—
50	12	7	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.

FRACTURE RADIOGRAPHS

Two radiographs of the elbow (75a) following the positioning shown in (74) disclose a fracture, in each case, through the head of the radius.

75a

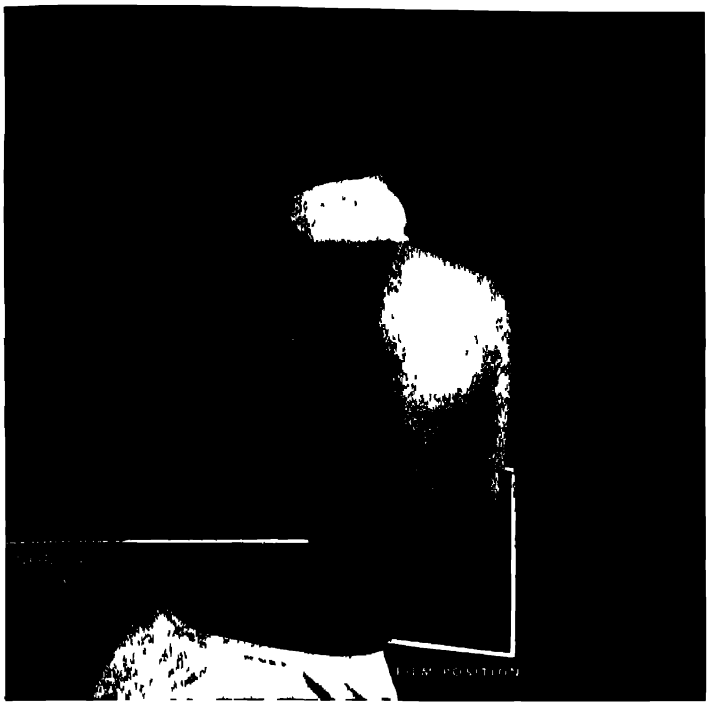
ADJUSTING X-RAY TUBE TO SUBJECT

Movement of a painful elbow from the lateral to the antero-posterior position should be avoided by lowering the tube of the ward trolley unit to elbow level and projecting the X-ray beam from the horizontal position.
(76)

Either splint or plaster may prevent the arm from being placed in the correct position in relation to the X-ray tube; it is then necessary to angle the tube in both positions in order to obtain true antero-posterior and lateral views. (77)

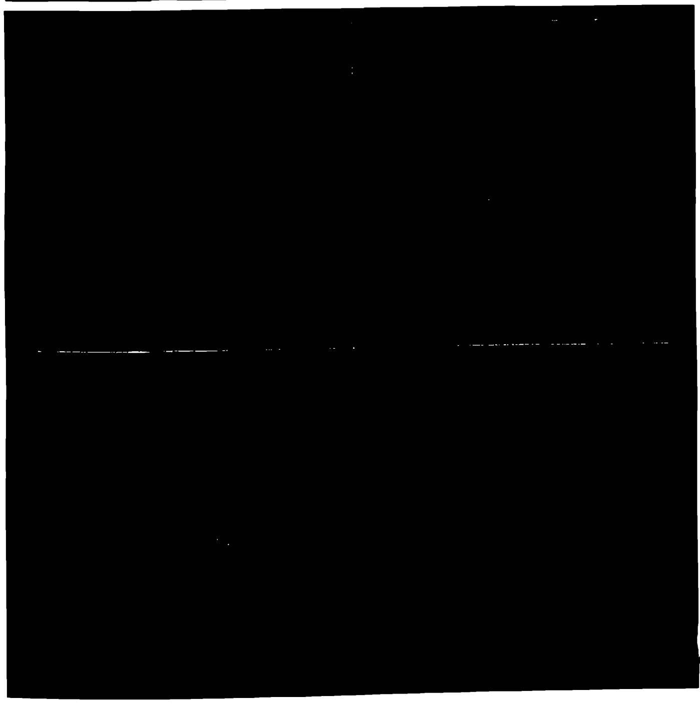
76

77



78

78a



79

Upper Extremity: Elbow Joint

ELBOW STRAPPED TO BODY—LATERAL

When the elbow is strapped to the body it is necessary to centre at right angles, through the trunk, to the lateral aspect of the elbow joint.

ERECT

The patient is allowed to stand with the lateral aspect of the elbow joint in contact with the vertical film, without regard to the position of the trunk.

The relationship between the patient and film plane is shown in (78), and the use of the grid is recommended and was applied in taking the radiograph shown in (78).

CENTRE, through the trunk, directly over the elbow joint. (78, 78a)

HORIZONTAL OR SITTING

When the patient is unable to stand, but is already sitting in a chair or is supine on the stretcher, the trunk is turned until the lateral aspect of the elbow joint is parallel to the film, which is placed toward the posterior aspect of the trunk.

CENTRE directly over the elbow joint.

It is necessary to increase the anode-film distance in order to avoid distortion due to elbow-film distance. In each case the relationship of the *elbow* to the film is important, although the trunk may be oblique in position to avoid overshadowing of the spine and elbow.

Postero-Anterior EXPOSURE FACTORS

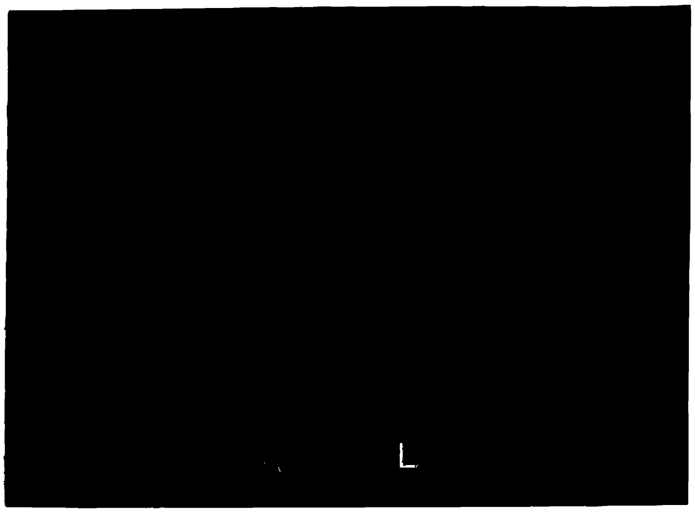
kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	74	45	30″	Ilford	Tungstate	—
75	102	62	30″	Ilford	Tungstate	Stationary
75	264	160	40″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in. or 10×8 in.

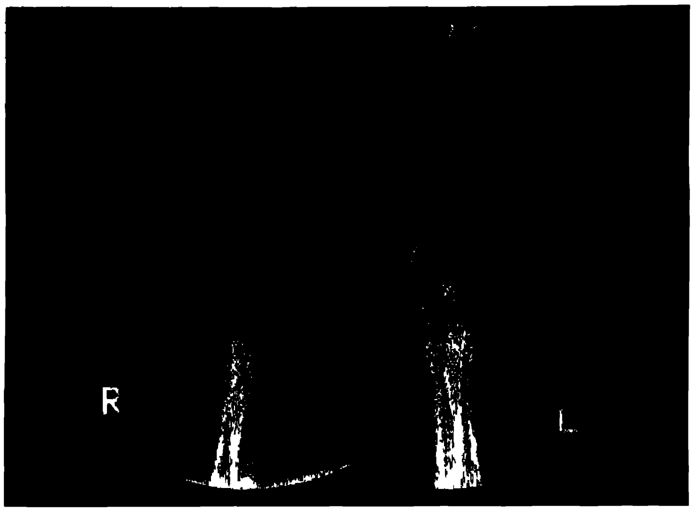
NOTE—The exposure time for the *postero*-anterior position should be increased by 50 per cent. when the *antero*-posterior position is applied.

DISLOCATION RADIOGRAPHS

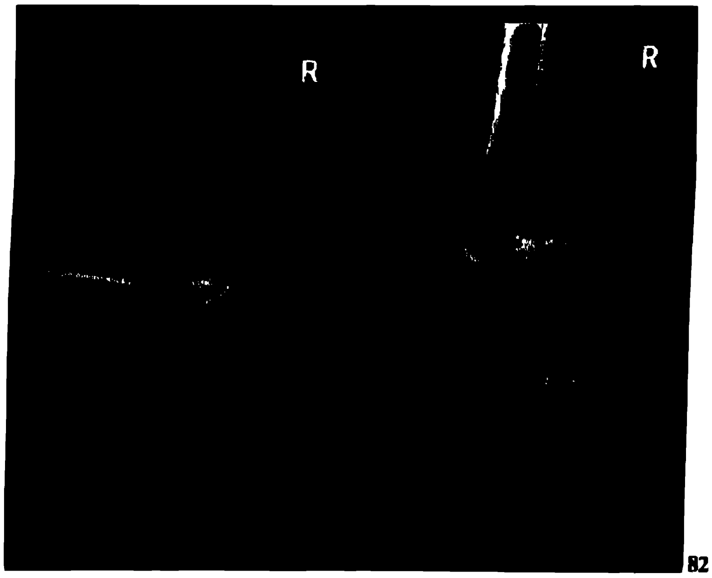
Films of injury to the elbow joint taken before, and later, following reduction of the dislocation, show that satisfactory comparative X-ray projection has been maintained (79).



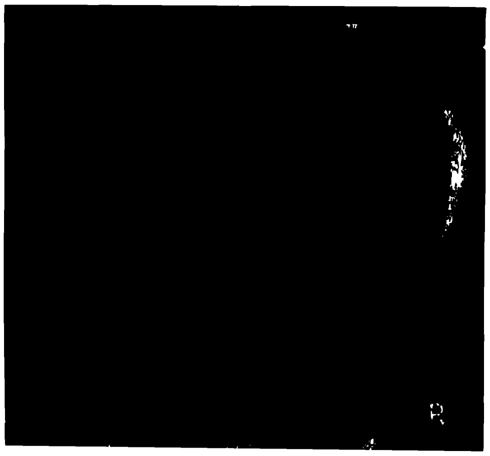
80



81



82



Upper Extremity: Elbow Joint

CHILDREN

In children *both* elbows are always radiographed, and in comparable positions, as shown in radiographs taken from the lateral and antero-posterior aspects.

(80, 81)

It is usual to make the two exposures from each aspect on the same film, as it is more convenient for comparison to have the two views of right and left sides permanently together and only two films to handle instead of four. A piece of lead is used to cover the portion of film not being exposed.

The illustrations **(80, 81)** and exposure factors are those in respect of a child aged seven years.

EXPOSURE FACTORS							
	mA. Secs.						
kVp.	Ilford Developers X-ray		Blue Label		Distance	Film	Screens Ilford
	A.P.	Lat.	A.P.	Lat.			
50	27	25	17	15	30″	Ilfex	—
45	41	37	25	22	30″	Ilfex	—
45	5	5	3	3	36″	Ilford	Tungstate

Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in.

It should be noted that antero-posterior views **(81)** show the effect of incomplete supination of the forearms, causing the radius to be superimposed on the ulna.

FRACTURE RADIOGRAPHS

The illustrations **(82, 83)** show a supra-condylar fracture in a child, the latter view having been taken from the lateral aspect after reduction of the fracture and subsequent immobilisation in a plaster splint.

SECTION 2

Humerus and Shoulder Girdle

HUMERUS AND SHOULDER GIRDLE

In examining the shoulder girdle respiratory movements have to be considered, as the bones of the shoulder move throughout the cycle of respiration. The patient's breath should be held and a short exposure time employed: exposures are usually made on expiration, as there is then little tension and the body is at rest, with the bones nearer to the film than on inspiration. In dealing with children and old people, and also with other cases in which respiratory movements cannot be controlled, the exposure time should be reduced to a maximum of one-tenth second.

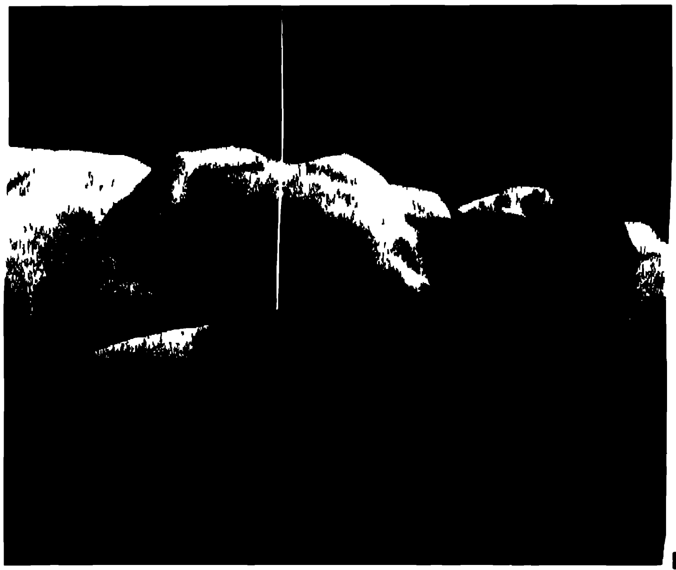
The choice of erect or horizontal position depends upon the condition of the patient. It is less disturbing to the injured subject, especially when elderly or obese, to be examined in the erect position and, when seriously distressed as the result of a recent accident, to be allowed to remain seated in the casualty chair: the examination is then carried out with the X-ray beam directed horizontally from the ward mobile unit. A little extra care taken in making a slight departure from everyday routine may add greatly to the comfort of the patient. In many departments the limitations of apparatus, chief of which is the lack of a tube which can be adjusted for horizontal projection, leave no choice to the operator but to carry out the examination with the patient on the couch.

Intensifying screens are usually employed, and the grid, either moving or stationary, is an asset, especially for lateral views taken through the trunk.

The exposure factors quoted in this section refer to an adult male subject weighing 168 pounds, having a height of 5 feet 11 inches, chest measurements, antero-posterior and lateral, of 8½ inches and 12 inches respectively, and a lateral shoulder to shoulder measurement of 16½ inches.

For smaller subjects the exposure factors should be varied by either a reduction of from 5 kilovolts to 10 kilovolts, or by reducing the milliampere-seconds by from 25 per cent. to 50 per cent.

NOTE—Where the kilovoltage is already less than 60 kilovolts the milliampere-seconds should be varied in preference to the kilovoltage.



84

84a

Humerus

It is rarely necessary to include both shoulder and elbow joint on the same film as there is usually an indication of abnormality within the upper two-thirds, which requires the inclusion of the shoulder joint, or within the lower two-thirds, which requires the inclusion of the elbow joint. For the latter, elbow joint technique is applied. The exposure factors are adjusted to each region as indicated in the exposure table, or, when both joints are to be included at a single exposure, a mean of the two sets of factors should be applied.

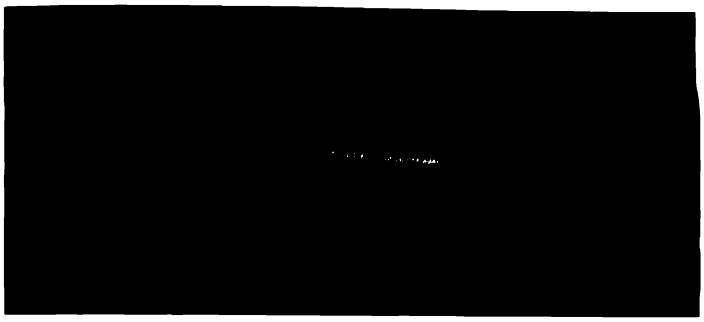
ANTERO-POSTERIOR

With the patient facing the tube, the trunk is rotated toward the affected side and the opposite shoulder raised on sandbags to bring the injured arm into contact with the cassette. The arm is supinated in full extension, with some abduction, and the forearm sandbagged in position. It is sometimes necessary to raise the cassette on sandbags to obtain contact, especially in dealing with a thickset subject.

CENTRE midway between the shoulder and elbow joint.

(84, 84a)


85


85a


86


86a


87

Humerus and Shoulder Girdle: Humerus

LATERAL

From the previous position the arm is rotated medially through 90 degrees and flexed at the elbow joint.

CENTRE midway between the shoulder and elbow joint.

(85, 85a)

NOTE—In both antero-posterior and lateral positions the film is placed well up under the shoulder joint as, in centring to the middle of the humerus, the oblique ray tends to project the shoulder joint, which is not in close contact with the film, to a much higher level than is generally anticipated.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray Upper	X-ray Lower	Blue Label Upper	Blue Label Lower	Distance	Film	Screens Ilford
50	50	24	32	16	36″	Ilford	Tungstate
70	148	74	90	45	36″	Ilfex	—
70	12	6	8	4	36″	Ilford	Tungstate

Film, 15 × 6 in. or 17 × 7 in.

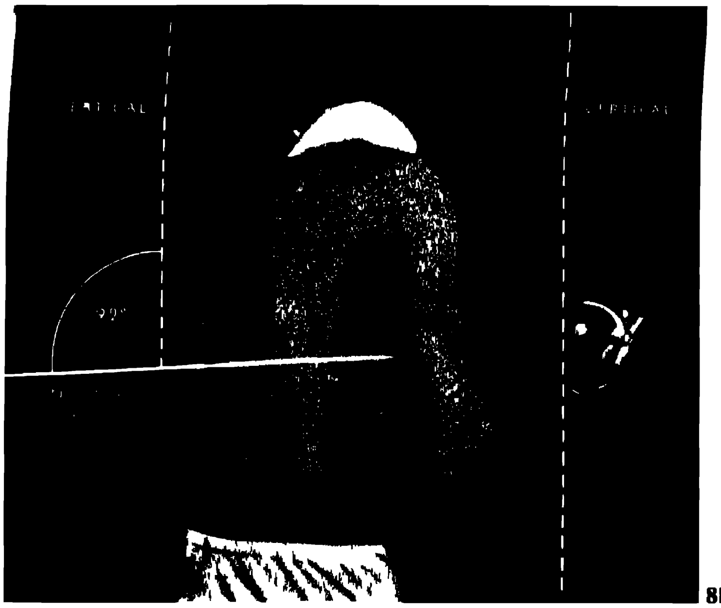
The erect positions for these two views of the humerus are shown on pages 43 and 45.

Methods of dealing with abnormal conditions are shown below and on pages 38, 39, 40, and 41.

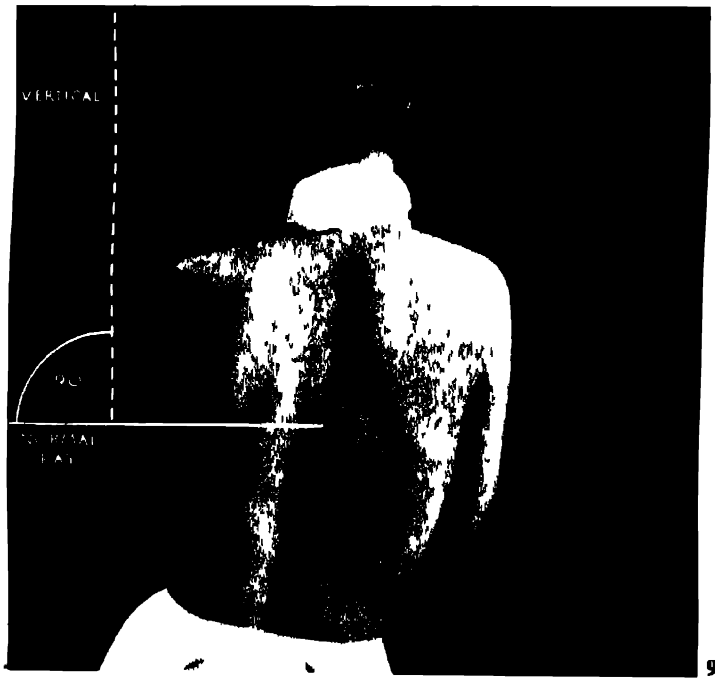
FRACTURE RADIOGRAPHS

The importance of obtaining two right-angled views of a fracture of the humerus is shown in **(86, 86a)**, where the method of splinting has complicated the positioning of the limb for the antero-posterior and lateral projections.

The radiograph of the baby **(87)** shows birth injuries to the clavicle and humerus. The limb is shown to be supported in a plaster splint and the exposure technique was adjusted to the reduced exposure time of one-tenth second, this being the maximum which can be allowed in the case of a young child on account of the difficulty of controlling its movements.


88


89



90

Humerus and Shoulder Girdle: Humerus

CONDITIONS REQUIRING SPECIAL TECHNIQUE, CHIEFLY APPLIED TO THE UPPER TWO-THIRDS OF THE HUMERUS

It is only on rare occasions that the previous ideal positions for the arm can be applied. It is more often necessary to improvise a suitable technique for each injured patient, the resulting films may not be spectacular from the pictorial point of view, but they will prove of great value to the surgeon in treating the patient.

The three photographs (88, 89, 90) illustrate some of the positions applied in treating the humerus when the arm is immobilised. The radiograph (91) shows the result of projecting the X-ray beam obliquely through the thorax.

1. When the arm is bandaged to the body the erect position should be used; the patient may sit or stand. Ignoring the trunk, the films should be placed to the lateral and antero-posterior aspects of the humerus, with the beam directed through the thorax when necessary (90). It is usually possible to obtain both antero-posterior and lateral views in fracture cases, the alignment of the fragments being clearly shown.

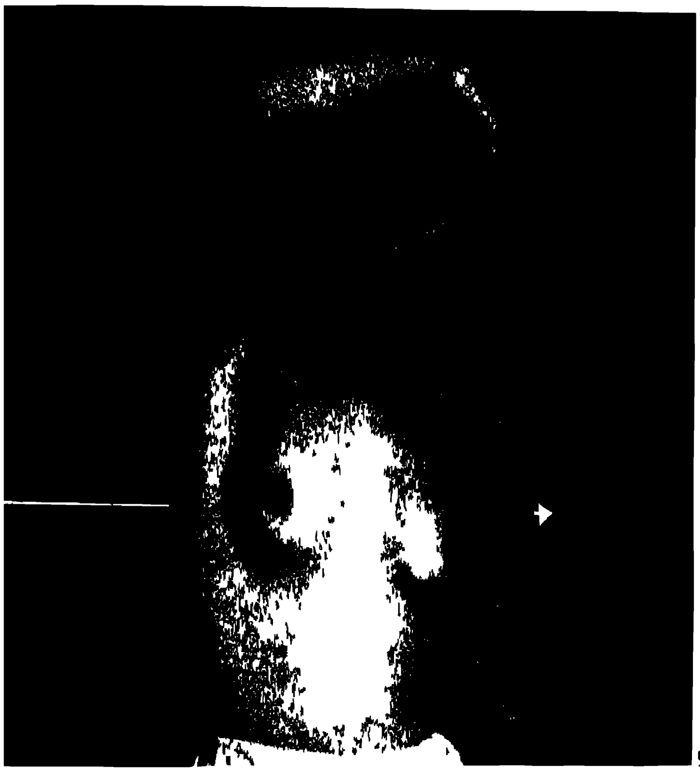
The following exposure factors apply to (90) and (91).

EXPOSURE FACTORS

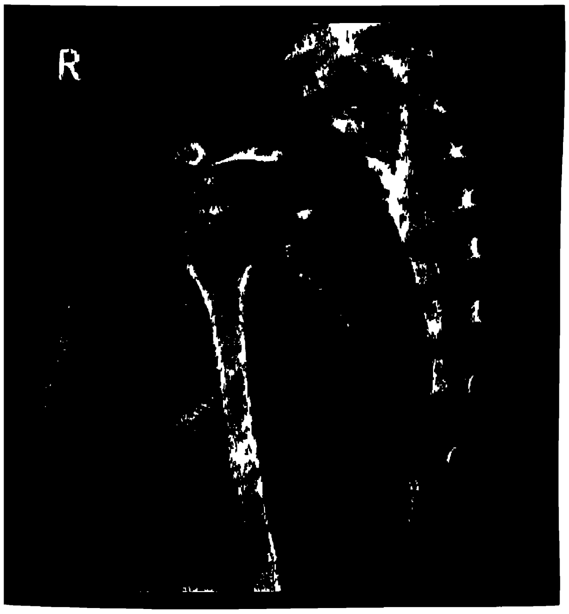
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	110	67	30″	Ilford	Tungstate	Potter-Bucky
85	55	34	30″	Ilford	Tungstate	Potter-Bucky

Film, 12 × 10 in. or 17 × 7 in

91



92



93

CONDITIONS REQUIRING SPECIAL TECHNIQUE *(continued)*

2. When the injured arm is hanging loosely beside the trunk and cannot be moved without causing pain, the patient should be placed in the erect or sitting position for both antero-posterior and lateral views. After taking the antero-posterior view the patient is placed in the lateral position, with the injured arm toward the film and with the opposite arm folded over the head so that the hand may rest on the film support, steadying the trunk, which leans toward the film, the affected shoulder assuming a lower level than the uninjured side. This position is an alternative to (89) and (90).

CENTRE through the axilla, to the upper third of the injured arm.

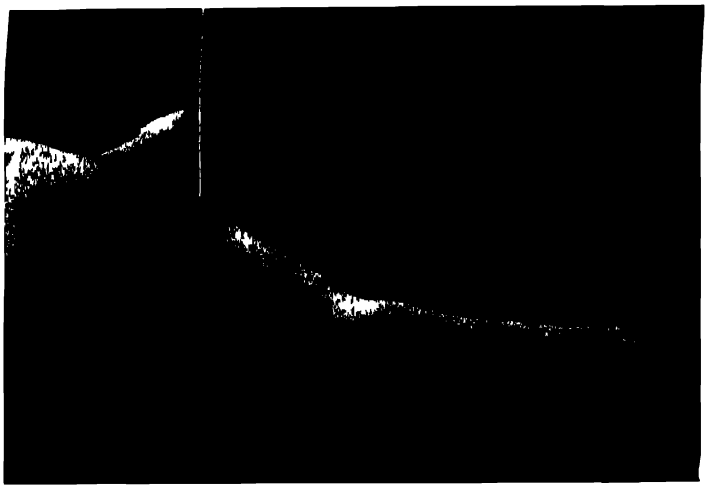
(92, 93)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	196	120	30″	Ilford	Tungstate	Potter-Bucky
85	140	85	36′	Ilford	Tungstate	Potter-Bucky

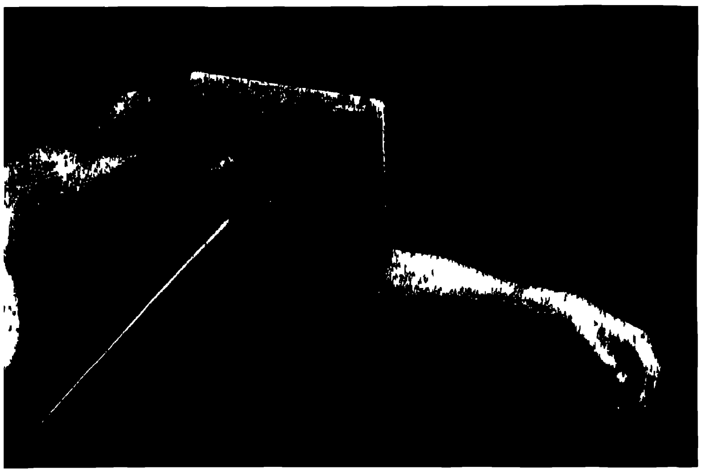
Film, 12 × 10 in. or 17 × 7 in.

NOTE—The outline of the humerus is very well shown, as will be seen in (93). Slight rotation of the trunk backward or forward, according to the position of the injured arm, is sometimes an advantage.

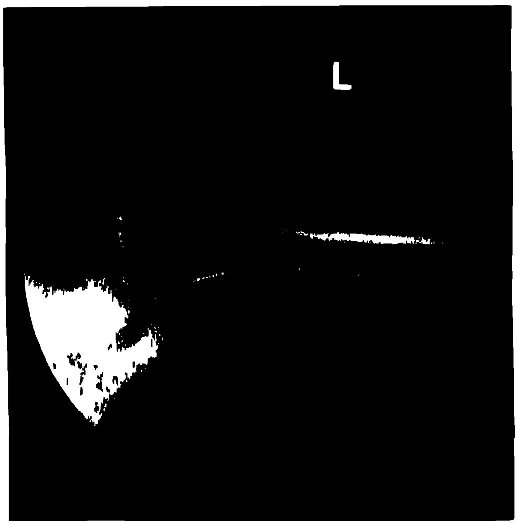


94

95



96



96a

Humerus and Shoulder Girdle: Humerus

CONDITIONS REQUIRING SPECIAL TECHNIQUE *(continued)*

3. When the arm is fixed by splint or plaster in abduction at an angle of from 70 degrees to 90 degrees with the trunk, the patient is examined in the supine position.

ANTERO-POSTERIOR

The injured arm is supported, and the cassette placed well up under the shoulder to include the shoulder joint and the upper third of the humerus.

CENTRE over the head of the humerus.

(94, 95)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	—
*60	35	20	30″	Ilford	Tungstate	—
70	16	10	36″	Ilford	Tungstate	—

Cone to size of film, 12 × 10 in. or 10 × 8 in.

* Ward mobile unit.

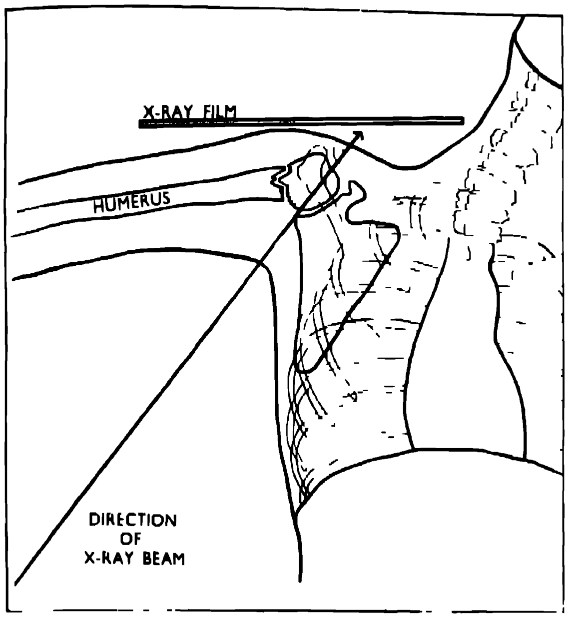
A plaster of Paris splint may require an increase of from 5 kilovolts to 10 kilovolts, according to the thickness of the plaster. Splints of the Jones or aeroplane types may obscure the bones unless the metal parts are of aluminium.

Special difficulties may occur in examining patients in the ward, as the abducted humerus may be awkwardly fixed for placing the film under the arm. The ward sister should be consulted in these cases.

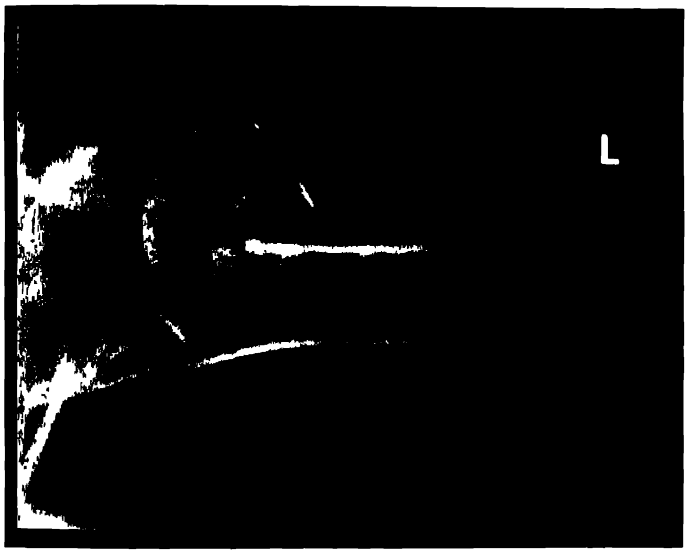
Unless a shock-free unit is available great care should be taken to see that the bed and X-ray unit are efficiently earthed, especially for the lateral view, where the tube is adjusted for horizontal projection and may be very near to the bed.

LATERAL

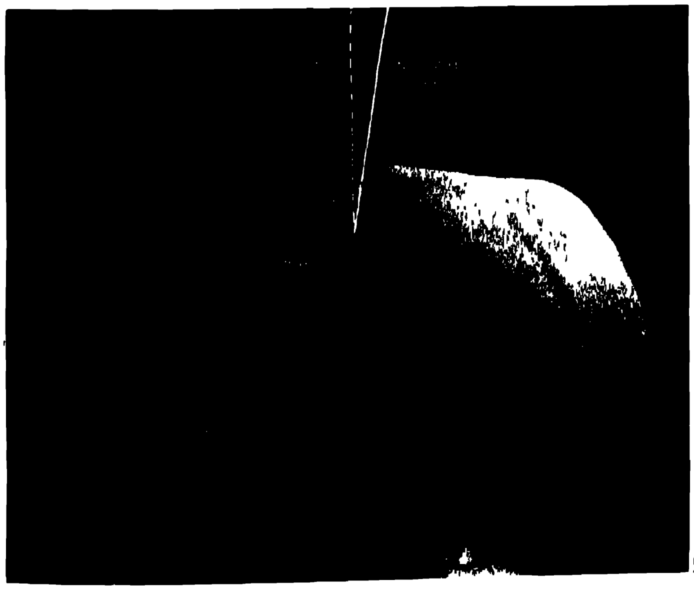
With the patient supine, the head and lower trunk are rotated away from the injured side, and support is given to the abducted arm. The cassette is placed on the superior aspect of the shoulder, well up into the neck, and maintained in position with sandbags (96).



97



98


99

CONDITIONS REQUIRING SPECIAL TECHNIQUE *(continued)*

The diagram from the antero-posterior aspect shows the importance of pressing the cassette well up into the neck to accommodate the oblique projection of the head of the humerus on to the film (97).

CENTRE through the axilla, with the tube adjusted to the horizontal position and angled toward the shoulder joint. (96, 96a, 97, 98)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	30	18	30″	Ilford	Tungstate	
75	20	12	44″	Ilford	Tungstate	

Cone to size of film, 10 × 8 in. or 12 × 6 in.

* Ward mobile unit.

The anode-film distance is increased to accommodate the tube at a safe distance from the patient and couch when the unit is not of the shock-free type, otherwise the 30 inch anode-film distance is satisfactory unless a very large splint prevents the close approximation of the cassette.

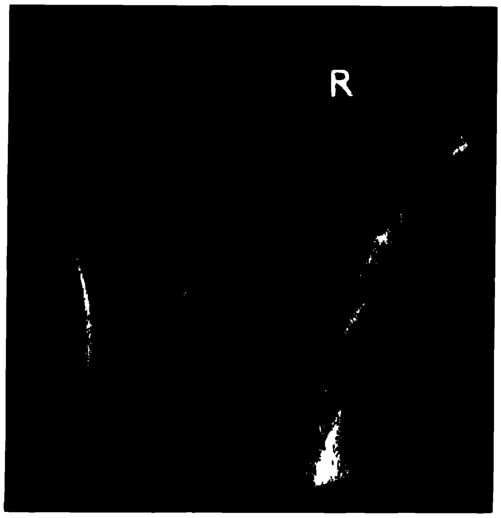
This method of lateral projection allows an undistorted view to be obtained under all circumstances. (98) is a typical radiograph and will be readily appreciated as a useful lateral view: in conjunction with the antero-posterior view (95) it gives all the necessary information in such cases. Metal splints and heavy plaster may partially obscure the bone, but the general alignment of the fragments can usually be seen.

Alternatively, the curved cassette may be used, placed well up into the axilla. The central ray is directed from above the shoulder joint at right angles to the general plane of the cassette (99), and the resulting radiograph is similar to that shown under (98).

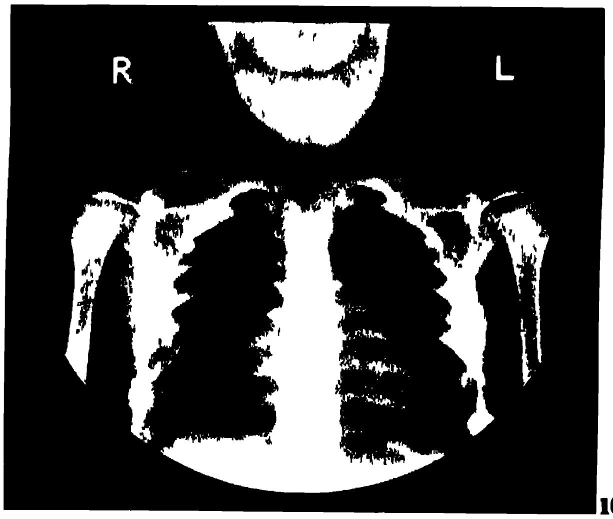
NOTE—This cassette cannot be accommodated to the axilla when the arm is on an abduction splint.

GENERAL NOTE—The difference in size of the radiographic images in (95) and (96a) is due to the variation in anode-film distance, i.e., from 30 inches to 50 inches. The increased anode-film distance is not necessary, however, when using the curved cassette.

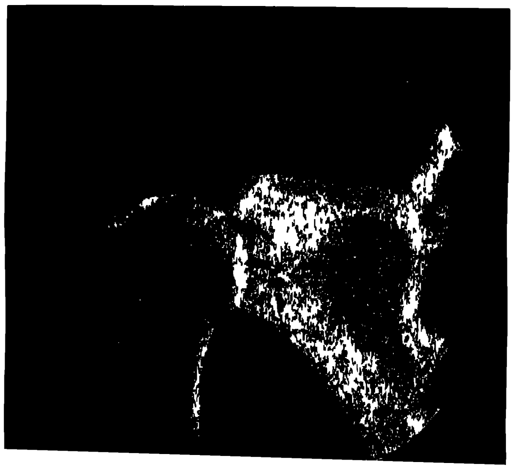
100



101



102



Humerus and Shoulder Girdle

Shoulder

GENERAL ANTERO-POSTERIOR

The patient is placed facing the tube, with the opposite shoulder raised and the head turned toward the affected side to assist close proximity of injured shoulder and film: when possible the arm is supinated and slightly abducted.

To avoid strain or jarring to the injured limb when the *horizontal* position is used firm support should be given behind the shoulders while lowering the patient into position.

CENTRE over the coracoid process (the bony prominence below the outer third of the clavicle). **(100, 101)**

NOTE—This view includes the gleno-humeral and the acromio-clavicular articulations, the lateral third of the clavicle, the proximal third of the humerus and the scapula adjacent to the glenoid cavity.

EXPOSURE FACTORS

kVp	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	—
*60	35	20	30″	Ilford	Tungstate	—
80	-	100	30″	Ilfex	—	Potter-Bucky

Cone to size of film, 12 × 10 in. or 10 × 8 in.

* Ward mobile unit.

CHILDREN

In young children it is essential to include both sides on the same film for comparison, the patient being placed in position after preparation has been made.

After making the necessary adjustments for a short exposure technique, the cassette is covered with a thin cloth to avoid the shock of cold contact and placed on the couch, with identification marker in position.

CENTRE the tube to the middle of the film. Finally the child is placed in position so that the mid-line of the thorax at shoulder level is approximately central to the tube and film **(102)**. See also birth injuries, page 37.

ACROMIO-CLAVICULAR ARTICULATION

The patient is placed in the same position as for shoulder joint examination, the erect posture being preferable.

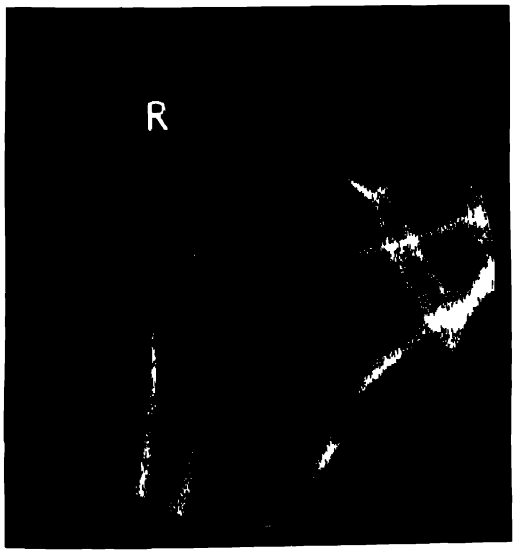
CENTRE over the humerus, at the level of the axilla.

The same exposure scale is used as for the shoulder joint, the penetration being reduced by 5 kilovolts **(103)**.

NOTE—The acromio-clavicular articulation is usually much over-exposed in the general view of the shoulder joint.

104

105



106

ANTERO-POSTERIOR TO SHOW JOINT SPACE

On examining the trunk from the posterior aspect it will be seen that the broad plane of the scapula is oblique in relation to the posterior and lateral aspects of the trunk. In order to obtain true antero-posterior views of the gleno-humeral articulation, the position of the trunk is ignored and the scapula placed parallel to the film.

The patient is adjusted in position so that the frontal plane of the trunk is at an angle of approximately 45 degrees to the film, the raised shoulder being supported on sandbags. In the final adjustment of the patient care should be taken to ensure that the broad plane of the scapula is parallel to the film, the arm being in partial abduction, with the elbow flexed. Erect and horizontal positions are equally satisfactory.

CENTRE over the head of the humerus.

(104, 105, 106)

EXPOSURE FACTORS

kVp	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	
*60	35	20	30″	Ilford	Tungstate	
70	16	10	36″	Ilford	Tungstate	

Cone to size of film, 12 × 10 in. or 10 × 8 in.

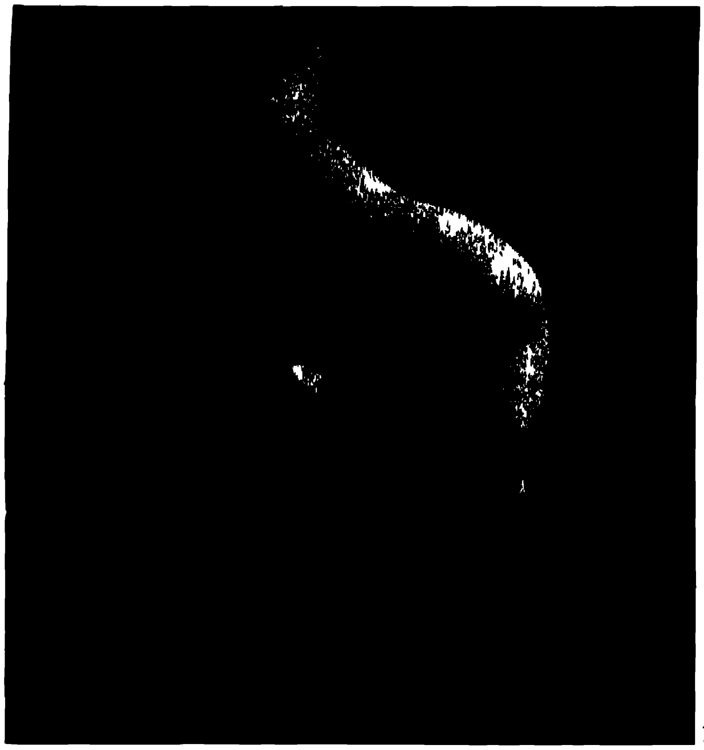
* Ward mobile unit.

NOTE—This view shows a clear joint space between the humerus and the glenoid cavity.

TUBEROSITIES OF THE HUMERUS

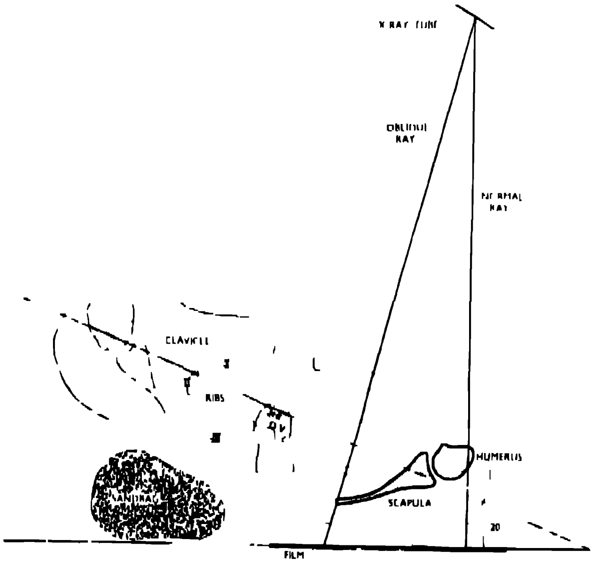
It is sometimes necessary to examine the site of insertion of the tendons of certain of the muscles of the shoulder joint.

The tendon of the *supraspinatus* muscle crosses the upper part of the shoulder joint to be inserted into the highest of the three impressions on the greater tuberosity of the humerus, and may be shown in radiographs taken in the antero-posterior position of the humerus, with the arm in full external rotation **(100, 101)**.



107

107a



108

TUBEROSITIES OF THE HUMERUS (*continued*)

The tendon of the *infraspinatus* muscle glides over the lateral border of the spine of the scapula, and passes across the posterior part of the capsule of the shoulder joint to be inserted into the middle impression on the greater tuberosity of the humerus. It is necessary, therefore, to angle the tube approximately 25 degrees toward the feet for the antero-posterior position **(100)**.

The upper fibres of the *teres minor* terminate in a tendon which is inserted into the lowest of the three impressions on the greater tuberosity of the humerus and the lower fibres of the muscle are inserted immediately below the impression. The termination of the muscle is, therefore, shown along the margin of the bone in antero-posterior radiographs taken with the arm in full *internal* rotation.

Exposures made in these positions serve to indicate the actual tendon concerned in an avulsion fragment of the tuberosities, and also to differentiate between this and calcification in a tendon.

The tendon of the *subscapularis* is inserted into the lesser tuberosity of the humerus and into the front of the capsular ligament of the shoulder joint. It is shown in lateral radiographs of the humeral head when the arm is abducted and externally rotated, the tube being directed toward the axilla, as in **(96, 96a)**.

AN UNUSUAL VIEW OF THE SHOULDER JOINT AND SCAPULA

The patient is placed obliquely in relation to the film, with the arm forward and upward beside the head.

CENTRE to the axillary border of the scapula.

(107, 107a)

As will be seen in the radiograph **(108)** the shoulder joint, acromio-clavicular joint, coracoid process and inferior angle of scapula are clearly shown.

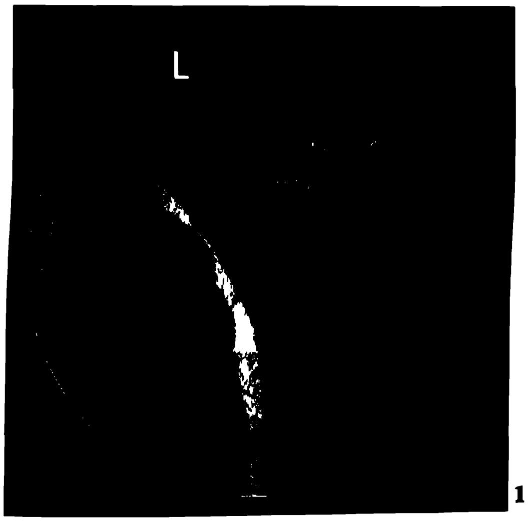
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	—

Cone to size of film, 12 × 10 in. or 10 × 8 in.

NOTE—This is an unusual position, limited in application to the freely movable shoulder joint.

109

110



111

112

Humerus and Shoulder Girdle

Scapula

Before radiographing the scapula it is essential to appreciate its anatomical position and variable relationship to the thorax as the arm moves through rotation, abduction and adduction, flexion and extension. Some of these variations are indicated in illustrations **(107, 108, 113, 114, 116)**.

When the shoulders are pressed back, with the arms adducted, the vertebral borders are parallel, and very near, to the spine. When the arms are brought forward and upward the scapulæ glide over the ribs in the same direction as the arms and rotate so that the vertebral borders are then oblique in relation to the spine. A selected span of this range of movement is adopted in demonstrating the bones radiographically, with careful adjustment of the trunk and centring of the X-ray tube to utilise the oblique rays.

ANTERO-POSTERIOR

The patient is placed in the supine position **(109)**, with the arm partially abducted and the opposite shoulder raised on a small sandbag. An alternative erect position is shown in **(110)**.

Too great a rotation of the body, as in **(104)**, allows the vertebral border of the scapula to overshadow mid-line structures of the thorax.

CENTRE over the head of the humerus.

(109, 110, 111, 112)

EXPOSURE FACTORS

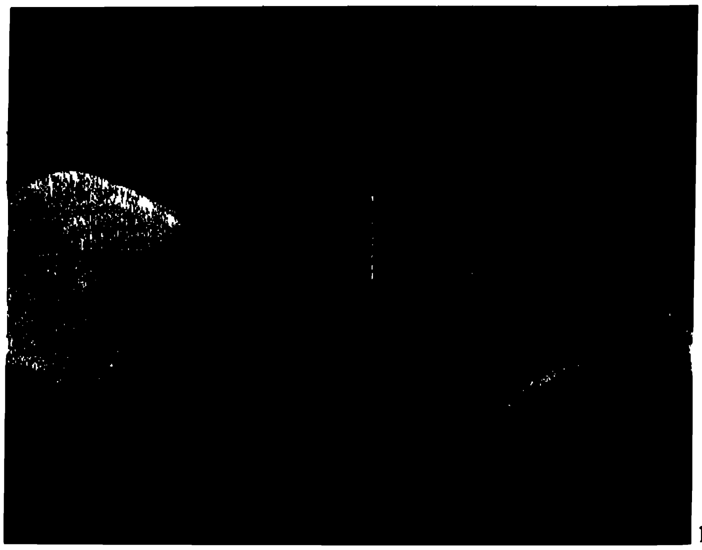
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	
*60	35	20	30″	Ilford	Tungstate	
70	16	10	36″	Ilford	Tungstate	

Cone to size of film, 10 × 8 in.

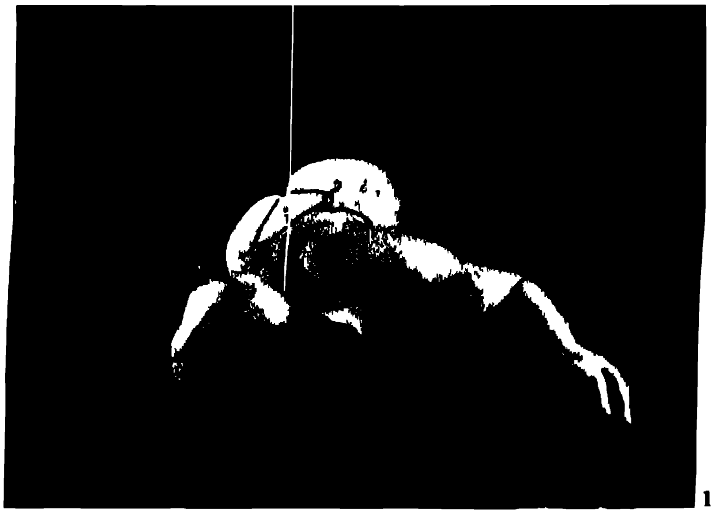
* Ward mobile unit.

NOTE—In addition to the shoulder region the maximum area of the body of the scapula is shown in this view. The vertebral border overlaps the axillary outline of the ribs, but is clearly visible owing to its close contact with the cassette **(111)**. See also fracture radiographs **(112, 115, 117)**.

The cross-sectional diagram shows the method of projecting the scapula undistorted and clear of the rib shadows **(108)**.



113



114

Humerus and Shoulder Girdle: Scapula

LATERAL

The patient is placed facing the film, with the opposite shoulder raised approximately 12 inches until the broad plane of the scapula is at an angle of from 75 degrees to 80 degrees to the film. The head naturally rotates away from the affected side for comfort. The arm is slightly abducted in order to separate the humeral shaft from the blade of the scapula

CENTRE over the fourth to fifth dorsal vertebra, with an open field, so that the oblique ray projects the scapula from the true lateral aspect

(113, 114, 114a, 114b, 116)

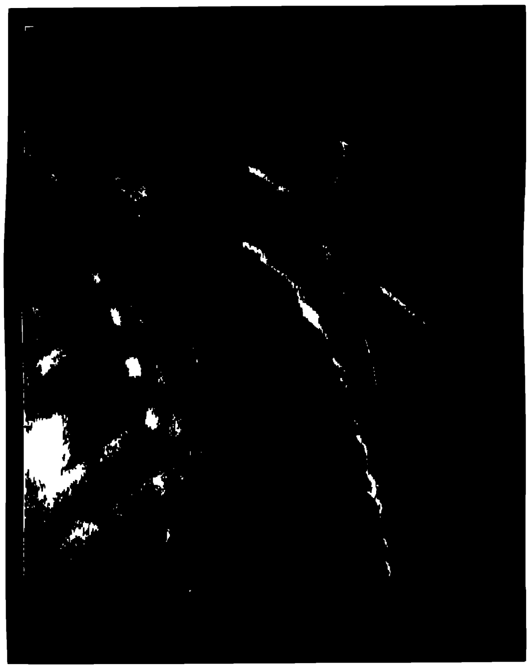
If a localising cone is preferred the tube is angled approximately 15 degrees away from the mid-line toward the mid-vertebral border of the scapula, when the central ray passes through the scapula from the vertebral to the axillary border

EXPOSURE FACTORS

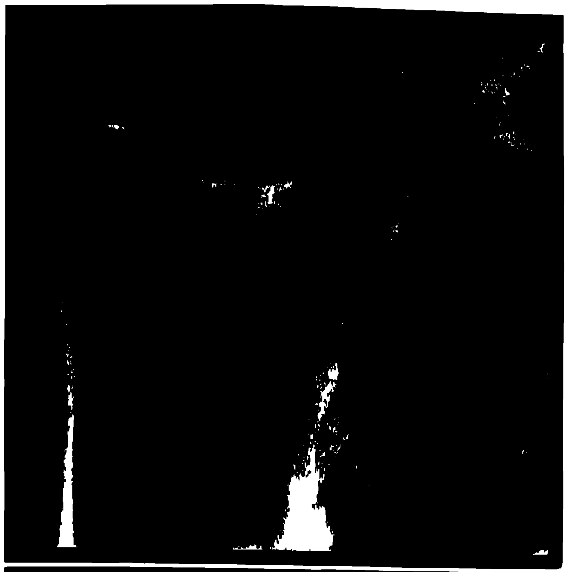
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	140	85	40	Ilford	Tungstate	Potter-Bucky
80	84	50	40	Ilford	Tungstate	Potter-Bucky
85	37	23	30'	Ilford	Tungstate	Potter-Bucky

Film, 12 10 in

114a



114b



115

115a

117

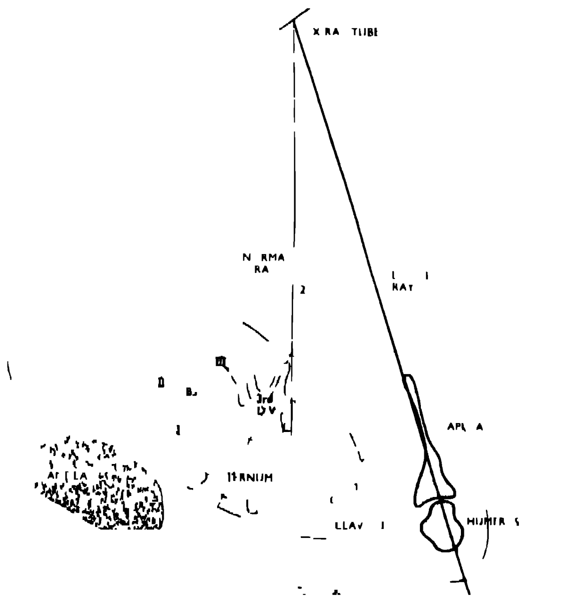
117a

Humerus and Shoulder Girdle: Scapula

LATERAL *(continued)*

NOTE—This view **(114b)** shows the head and upper third of the shaft of the humerus, with the scapula edge on, from axillary to vertebral border, and with coracoid and acromion processes medial and lateral, respectively, to the superior angle. Fracture displacements and dislocations are demonstrated **(115a, 117a)**.

The cross-sectional diagram **(116)** shows the method of projection in the horizontal position shown in **(113, 114)**.



116

The horizontal position may appear to be somewhat drastic for the injured patient, but in practice there is no difficulty in obtaining this position once the patient has been carefully lowered on to the X-ray couch. When suitable equipment is available the erect position is equally satisfactory **(114a)**.

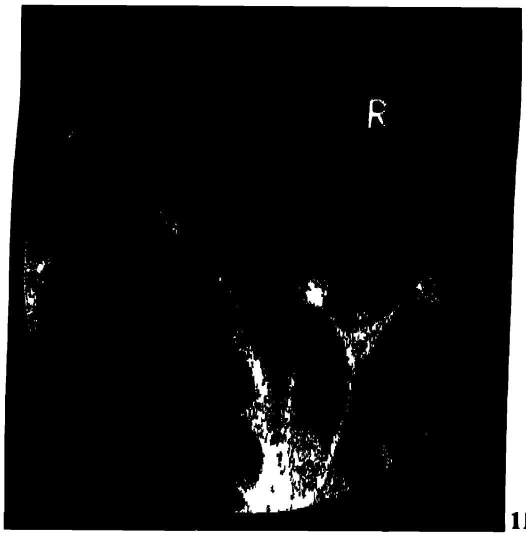
FRACTURE RADIOGRAPHS

Two pairs of radiographs showing fractures of the scapula, antero-posterior **(115, 117)** and lateral **(115a, 117a)**, confirm the value of taking the additional lateral view. This position for the lateral view, will in most cases be found to give less discomfort to the patient than the supine position for the antero-posterior view, and might well be the first position taken.

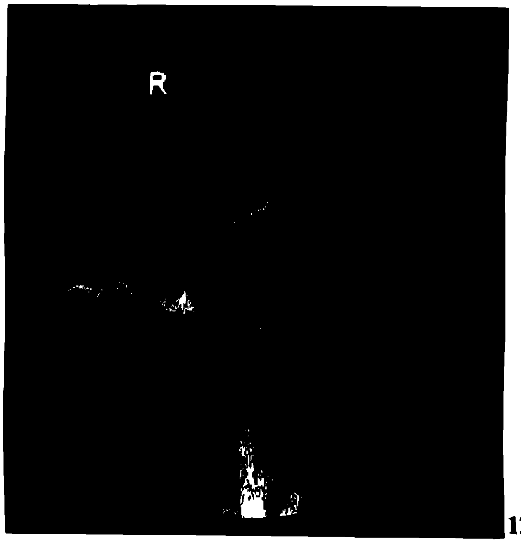
NOTE—A stationary grid was used for taking the lateral radiograph **(117a)**.

Humerus and Shoulder Girdle

118



119



120

Clavicle

POSTERO-ANTERIOR

The patient is placed facing the film, with the head turned away from the affected side to allow the clavicle to make good contact with the cassette. The arm is rotated medially until the palm of the hand faces upward, and the opposite shoulder is raised and supported on a small sandbag. In placing the patient in position on the cassette the line of the clavicle should be followed obliquely downward from the acromio-clavicular to the sterno-clavicular joint, the latter being at the posterior level of the fourth dorsal vertebra.

CENTRE to the superior angle of the scapula.

(118, 119)

NOTE—In positioning the cassette the long border should not be placed parallel to the soft tissue contour of the shoulder and neck, or the sternal end of the clavicle will be projected off the lower central border of the film, especially when a small film is employed.

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	36″	Ilford	Tungstate	—
*60	35	20	30″	Ilford	Tungstate	—
70	16	10	36″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in. or 12 × 10 in.

* Ward mobile unit.

NOTE—The different appearance of the shoulder joint from postero-anterior and antero-posterior aspects should be noted.

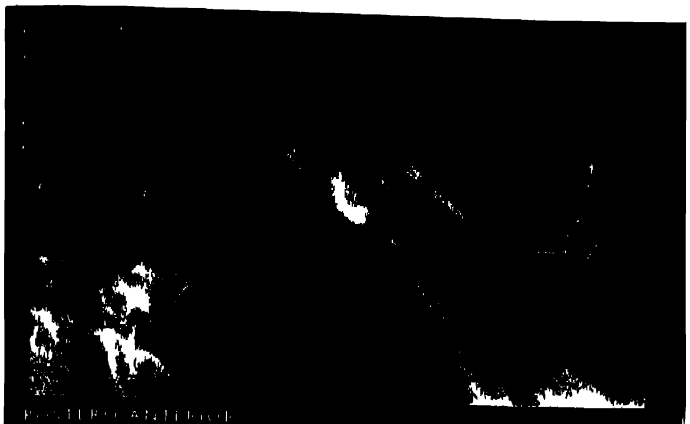
(119, 120, 121, 121a)

ANTERO-POSTERIOR

When the condition is painful and facilities do not allow of the erect position the supine should be used, following the same procedure as applied for the general antero-posterior view of the shoulder joint (100).

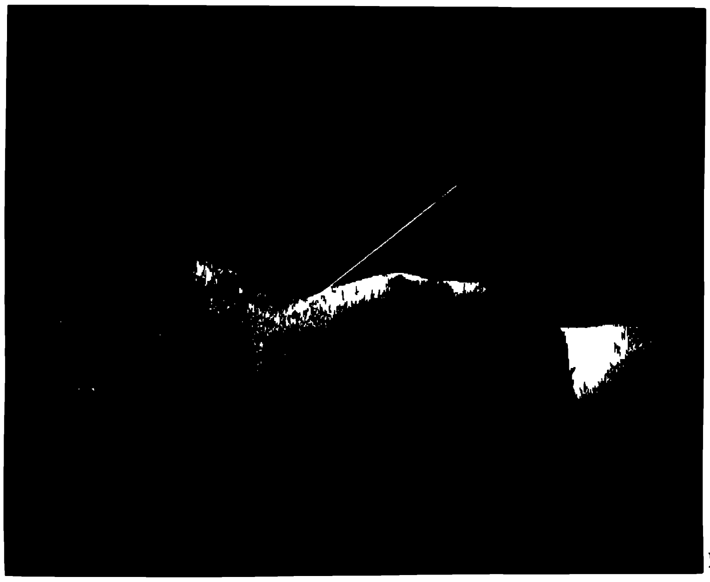
CENTRE to the middle of the clavicle.

(120)



121

121a



122

122a

FRACTURE RADIOGRAPHS

Two radiographs, postero-anterior (121), and antero-posterior (121a), taken before, and after, reduction of a fracture of the clavicle, are not suitable for comparison because of the difference in projection. It is suggested, however, that for fracture work these two views might well be taken in place of the right-angled views which are normally made of most other regions of the body.

CHILDREN

In young children, right and left clavicles are included on the same film, with the patient in the supine position as in taking the shoulder joints (102). See also birth injuries, page 37.

INFRA-SUPERIOR

The patient is supine, with the frontal plane of the trunk parallel to the couch. The shoulder of the affected side is depressed, with the arm adducted and the hand facing toward the trunk. The head is rotated well over to the opposite side, with the chin in contact with the shoulder. The cassette is supported by sandbags at an angle of approximately 20 degrees from the vertical to be at right angles to the central ray, with its lower border toward the shoulder, and is pressed well up into the neck, parallel with the long axis of the clavicle.

CENTRE one inch from the sternal end of the clavicle, with the tube angled 35 degrees to the horizontal and 15 degrees outward toward the shoulder.

(122, 122a)

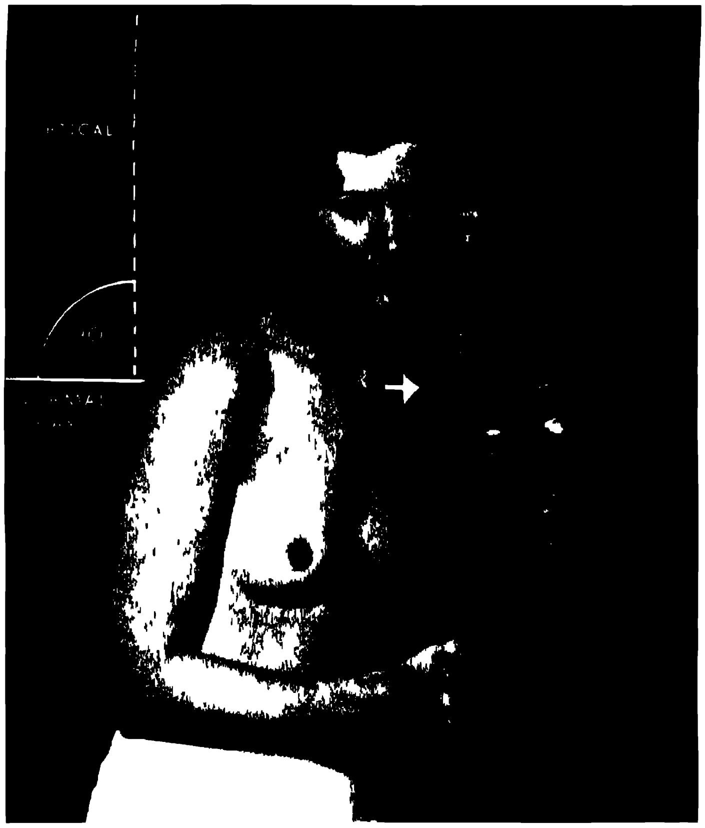
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
67	120	73	40″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in. or 12 × 10 in.

NOTE—This view (122a) shows the clavicle separated from the ribs, thus giving a second view to the postero-anterior or antero-posterior position.

123



124

125

Humerus and Shoulder Girdle

Sterno-clavicular Joints

From the antero-posterior aspect the comparatively light structures of the sterno-clavicular joints are overshadowed by the heavier densities of the spine, necessitating either oblique projection to separate the two shadows or a short distance technique to obtain diffusion of the spine shadow. The wide separation of the two regions, although variable from subject to subject, allows the following technique to be applied without undue difficulty.

POSTERO-ANTERIOR, TRUNK ROTATED, TUBE STRAIGHT

With the patient facing the film, the trunk is rotated to an angle of 45 degrees, so that, from the tube position in relation to the film, the spine and sternum are separated. This allows the clavicle and sterno-clavicular joint of the one side to be near the film, with the spine rotated to overshadow the mid-third of the same side. Erect and horizontal positions are shown.

CENTRE at the level of the fourth dorsal vertebra, 4 inches from the mid-line and toward the side turned from the film.

(123, 124, 125, 126, 127, 128, 129)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
45	55	33	30″	Ilford	Tungstate	—
70	82	50	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 8½ × 6½ in.

Two films should always be taken, to show right and left sides. In each film both joints are projected to one side of the spine—the joint nearer the spine is shown satisfactorily, but the further joint is foreshortened and distorted. An open field has been used in taking these radiographs **(125, 128)** to enable the relationship between the various structures from the oblique aspect to be appreciated. A small localising cone improves definition. The R or L marker indicates the joint shown to advantage, and not the side of the film.

126

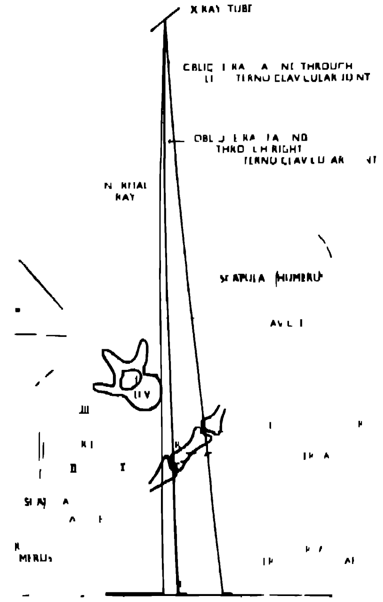
127

128

Humerus and Shoulder Girdle: Sterno-clavicular Joints

POSTERO-ANTERIOR, TRUNK ROTATED (*continued*)

The cross-sectional diagram shows the method of projecting the sterno-clavicular joints clear of the spine shadows, in this instance giving a satisfactory view of the right side (**129**).



129

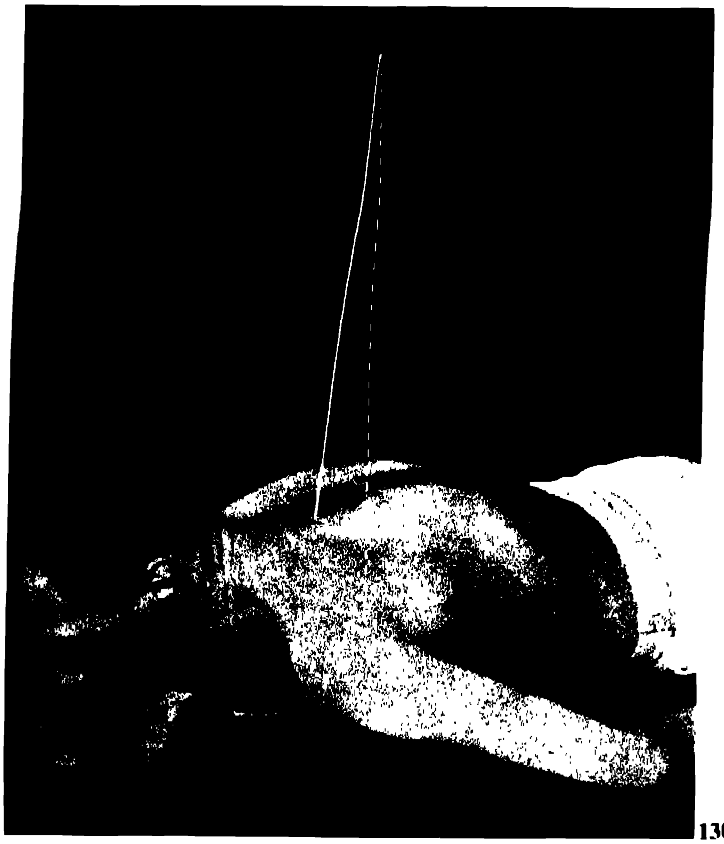
POSTERO-ANTERIOR, TUBE ANGLED, TRUNK STRAIGHT

There is always less distortion shown in the radiograph when the region under examination is parallel and in close proximity to the film. Under these conditions the necessary separation of the sternum and spine shadows is obtained by angling the tube.

The practical worker will appreciate the necessity for the variation in tube displacement and in anode-film distance, according to the thickness of the subject, to allow the necessary separation of sternum and spine shadows. The following procedure will serve as a guide to correct positioning, and should ensure the production of satisfactory films.

The thickness of the patient is measured from the antero-posterior aspect at the level of the sternal angle. This measurement indicates the necessary tube displacement *from* the spine before angling the tube *toward* the spine. It is also *one-third* of the appropriate anode-film distance.

The patient is placed facing the film, with the chin over the edge of the cassette, so that subject-film distance is minimised.



130

Humerus and Shoulder Girdle: Sterno-clavicular Joints

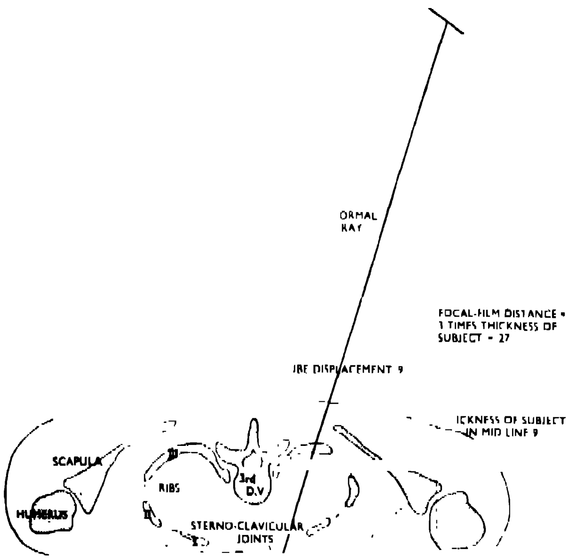
POSTERO-ANTERIOR, TUBE ANGLED, TRUNK STRAIGHT *(continued)*

CENTRE the tube over the right or left shoulder as required, at the level of the fourth dorsal vertebra, allowing the necessary displacement from the spine, and from this off-centre position angle the tube 18 degrees toward the spine. **(130, 131, 132, 133)**

NOTE—Exposure factors are easily adjusted to the patient by calculating exposure time according to the distance variation in conjunction with the factors quoted below.

EXPOSURE FACTORS							
	mA. Secs.						
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	55	33	30″	Ilford	Tungstate	Stationary
45	55	33	30″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in. or $8\frac{1}{2}$ × $6\frac{1}{2}$ in.



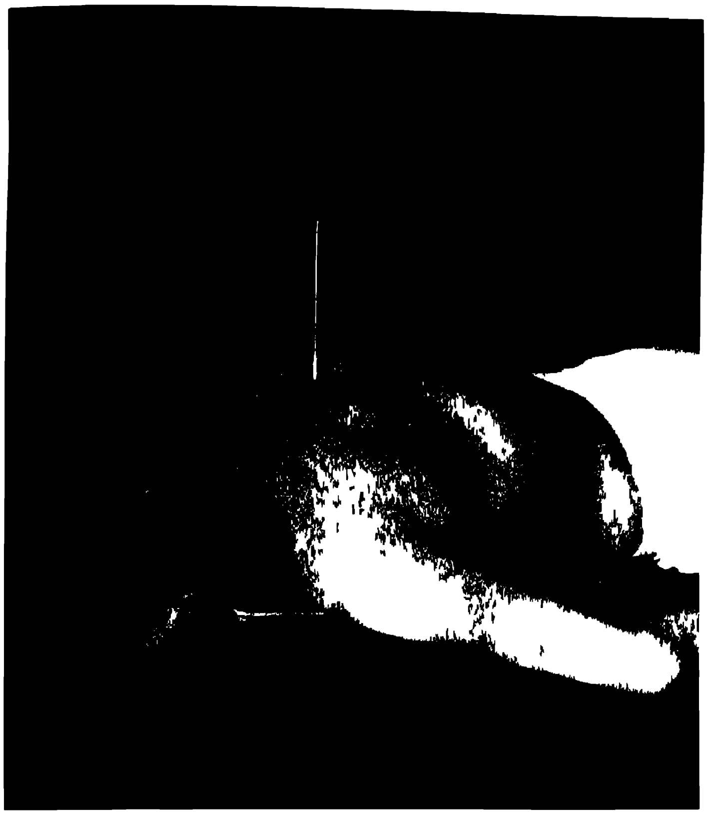
131

The cross-sectional diagram shows the method of projection and the significance of the calculated tube displacement and anode-film distance according to the thickness of the patient **(131)**.

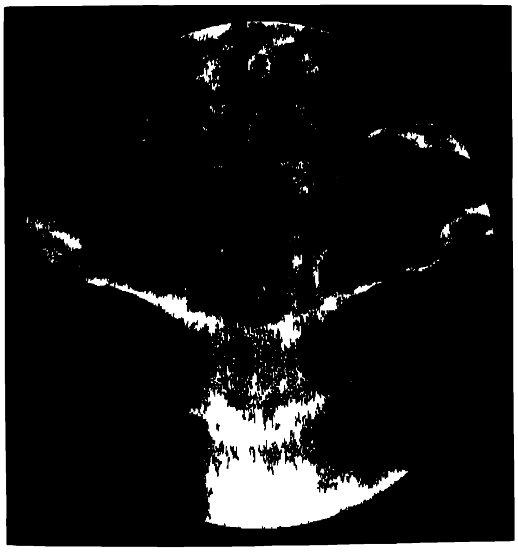
By this method only one sterno-clavicular joint is shown in each film; it is clearly defined and free from distortion. This technique may be applied equally well with the patient in the erect position.

132

133



134



135

Humerus and Shoulder Girdle: Sterno-clavicular Joints

SHORT-DISTANCE TECHNIQUE

The patient is placed in the true postero-anterior position with the film in contact with the sterno-clavicular joints It is necessary to apply an anode-film distance of approximately 15 inches, allowing a minimum of 3 inches between tube and skin surface

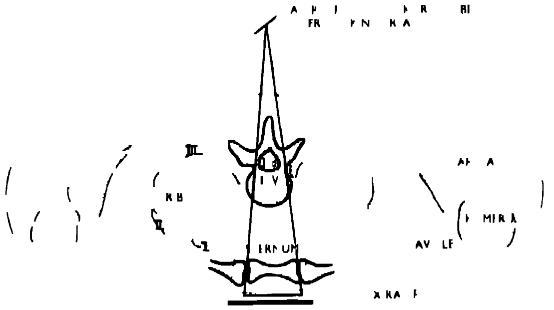
CENTRE over the fourth dorsal vertebra

(134, 135, 136)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
45	25	15	15	Ilford	Tungstate	—
60	25	15	15	Ilford	Tungstate	Stationary

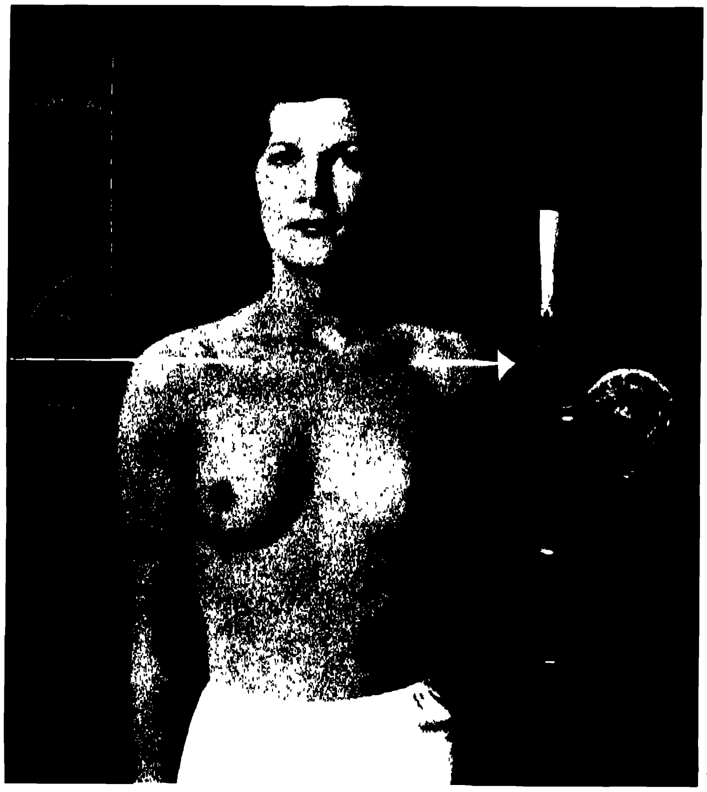
Film, 8½ 6½ in or 6½ 4¾ in

NOTE—The short anode-film distance gives a diffused image of the spine, due to the fact that it is almost mid-way between film and anode, while the sterno-clavicular joints, which are in contact with the film, are shown clearly and without distortion

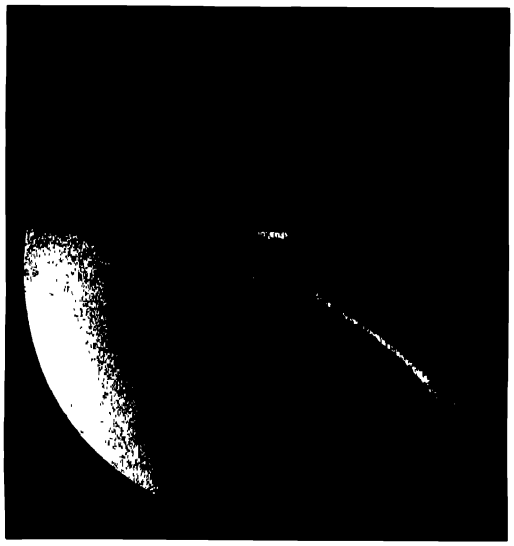


136

WARNING—*Do not make a number of repeat exposures at this short tube-subject distance.*



137



138

Humerus and Shoulder Girdle: Sterno-clavicular Joints

LATERAL

The patient is placed in the true lateral position, with shoulders and arms well back. The exposure is made on inspiration.

CENTRE through the sterno-clavicular joints.

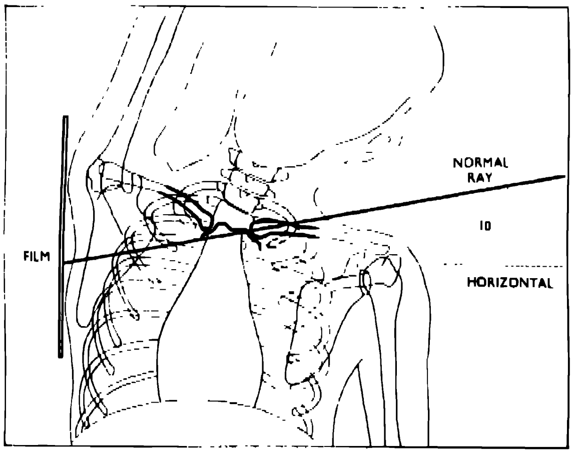
(137, 138)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	140	84	60″	Ilford	Tungstate	Potter-Bucky
70	35	20	60″	Ilford	Tungstate	—

Film, 10 × 8 in. or $8\frac{1}{2} \times 6\frac{1}{2}$ in.

Another method of showing this region from the lateral aspect is by adopting the positioning technique shown in diagram (139), in which the sterno-clavicular joints are projected between the shoulder levels, both trunk and tube being angled to obtain vertical separation of the shoulder joints. The position of the patient will be similar to that shown in illustration (92), page 39, the positions of tube and film being reversed. The diagram is composed of tracings from two radiographs taken simultaneously of the same subject to show soft tissue and bone structures.



139

The sterno-clavicular joints are also clearly shown from the lateral aspect when the centring point is at the level of the third cervical vertebra as for lateral cervical technique.

SECTION 3

Lower Extremity

LOWER EXTREMITY

A unit in which the tube is easily adjusted to any position in relation to the patient is particularly desirable in radiographing the lower extremity. Patients are conveyed to the X-ray department by chair or trolley, and much unnecessary pain and discomfort is caused by lifting them on and off the X-ray couch, and by rotating the limb from antero-posterior to lateral position. In addition, there may be considerable waste of time and labour, as two or more assistants are required to move a heavy patient. It is an advantage to house a mobile unit in a room of suitable size, so that the casualty trolley or chair may be also accommodated there for all examinations of the lower limb, especially in the case of gross injuries.

Comfortable relaxation in the various positions is important in order to immobilise the limb adequately.

Adjustable back and foot rests are an essential part of every X-ray couch. Nothing is more uncomfortable for the patient than to sit on a hard wooden table with the legs extended at right-angles to the trunk, without a back support, and to maintain that position during the exposure. There is always the choice of the general recumbent position, but most patients suffering from a minor injury prefer to see what is happening, and if at all nervous they will have more confidence if allowed to remain in a sitting position.

Splints and appliances are never removed without permission from the doctor attending the patient. In these cases, and when plaster has been applied, the correct centring point and the position for the film may be determined by comparison with the sound limb (140). It is essential to show the relationship between the adjacent joint and the site of fracture, and exclusion of the joint through faulty centring is inexcusable.

The exposure factors quoted in this section refer to an adult male subject weighing 160 pounds and having a height of 5 feet 8 inches

For smaller subjects the kilovoltage should be reduced by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent. Where the kilovoltage is already less than 60 kilovolts, the milliampere-second variation is the more satisfactory.

ANATOMICAL NOMENCLATURE

As both old and new anatomical terminologies are in general use, the following alternative terms having reference to this section are quoted for guidance.

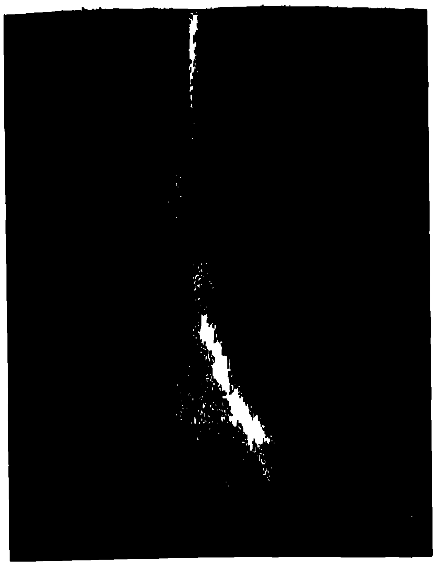
NEW	OLD
Talus	Astragalus
Calcaneum	Os Calcis
Navicular	Scaphoid
Cuboid	Cuboid
Cuneiform	Cuneiform


140

Foot

The bones of the foot form a series of curves—the transverse and longitudinal arches of the foot. In addition, the general plane of the foot is oblique in direction from proximal to distal—ankle to toes, and medial to lateral —inner to outer side.

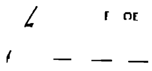
This obliquity of the foot is accompanied by a variation in thickness and, therefore, in the radiographic translucency of the bones. These characteristics have to be considered in radiographing the foot, and necessitate the four positions shown on page 57, two of which are applied in each case according to diagnostic requirements.



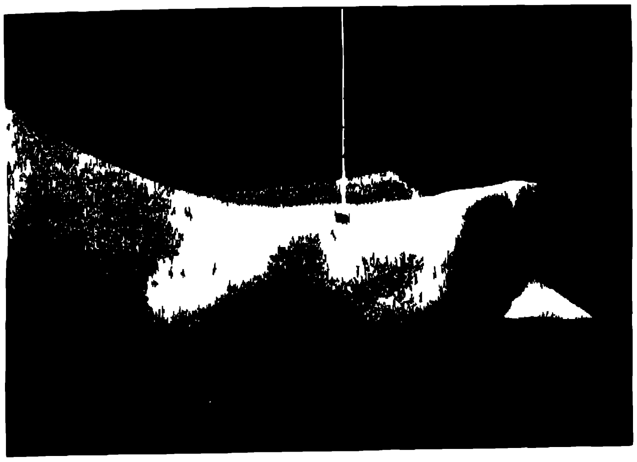
142

Lower Extremity: Foot

On a low kilovoltage technique contrast in density between the thin and thick portions of the foot is so marked that only one region may be shown satisfactorily These differences in regional density are reduced by using a higher kilovoltage, which produces a film of reasonable diagnostic value A suitably made wedge of evenly translucent material (**141**) placed between foot and film serves to even up the varying density of the foot



141



143

Shading of the toes with lead during the exposure is equally effective but should be done with an automatic shading device, as hand shading, if applied without due precaution, is accompanied by grave risk of over-exposure to the operator and should not be encouraged

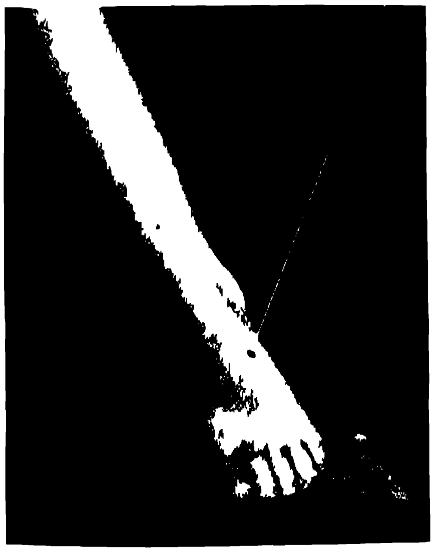
The four positions described in the following pages are here shown for comparison They are

(**142**) Dorsi-Plantar— when the foot is bearing the full weight of the body

(**143**) Lateral—when the sole of the foot is at right-angles to the film

(**144**) Dorsi-Plantar Oblique—when the dorsum of the foot is at right-angles transversely to the normal ray from the X-ray tube

(**145**) Oblique when the sole of the foot is oblique in relation to film and X-ray beam

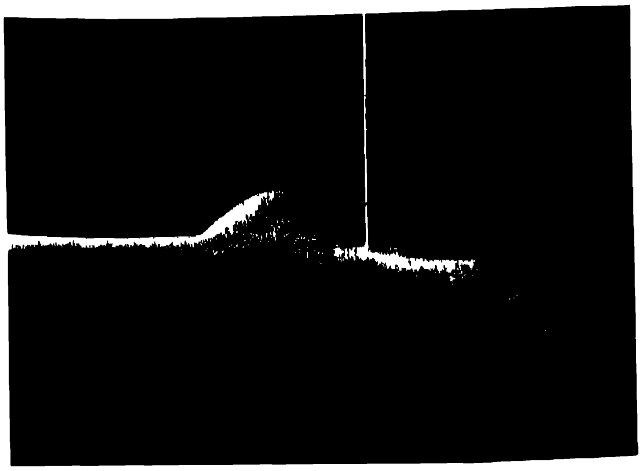


144

As the oblique positions are the more frequently used they are given precedence in the text

The term dorsi-plantar" replaces the term "antero-posterior" as applied to other joints

NOTE—Inversion and eversion of the foot are movements whereby the sole of the foot is turned in a medial or lateral direction respectively These terms are often incorrectly applied to the movement of rotation of the limb as a whole medially or laterally



145

Lower Extremity: Foot


146

DORSI-PLANTAR OBLIQUE (1)

With the patient supine or resting semi-recumbent against a back rest, the knee is flexed with the plantar aspect of the foot in contact with the film: the knee is then allowed to lean medially to bring the transverse plane of the dorsum of the foot as nearly parallel to the film as possible, with the other limb as a support to assist *immobilisation*

CENTRE to the navicular-cuboid articulation, with the tube angled from 10 degrees to 15 degrees medially and from 10 degrees to 15 degrees toward the ankle joint, so that the normal ray is at right-angles to the general plane of the dorsal surface **(146, 147, 148, 149)**

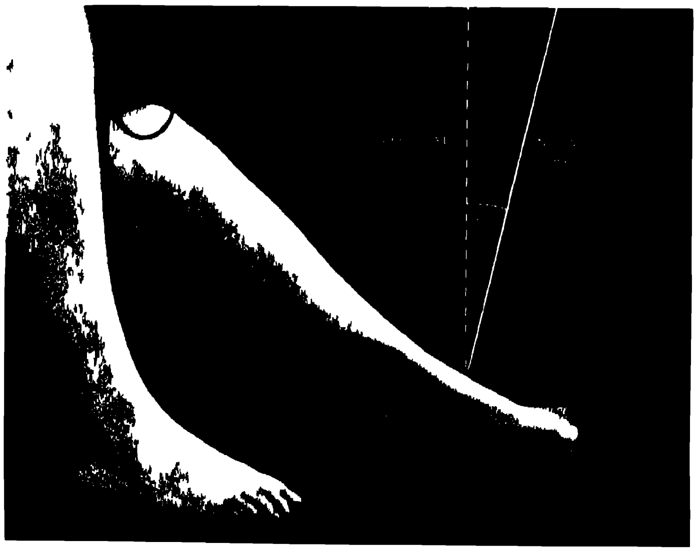
NOTE —Inexperienced workers should be especially careful in centring the tube when making the double tube angulation, and should confirm, *after* angling the tube, that the normal ray is directed toward the correct centring point

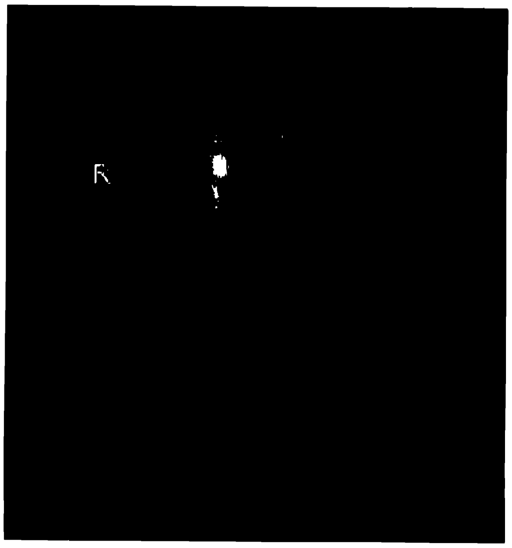

147

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30	Ilfex	–	–
*70	26	16	30	Ilfex	–	
60	5	3	36	Ilford	Tungstate	–

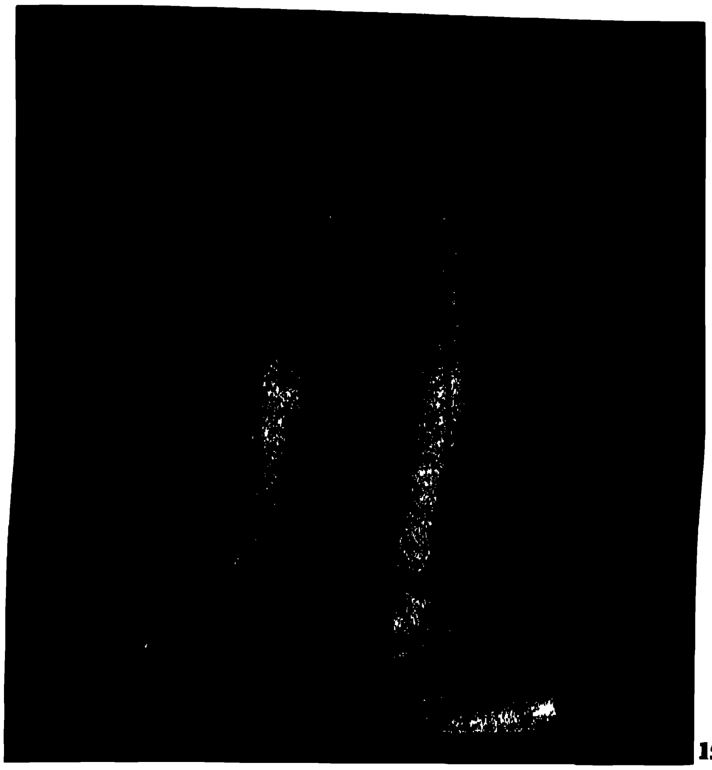
Cone to size of film 12 × 6 in

* This is the most suitable kilovoltage to produce similar densities in both phalanges and tarsal bones


148

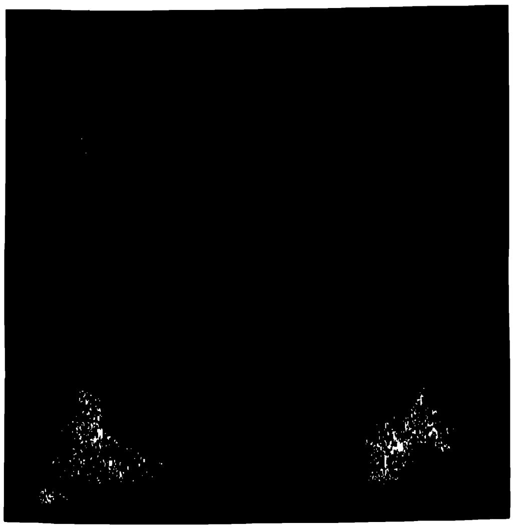


149



150

151



152

Lower Extremity: Foot

DORSI-PLANTAR OBLIQUE (2)

Workers who prefer to dispense with tube angulation should prepare a wedge of evenly radio-translucent material such as paraffin wax, cardboard or wood similar to lignum vitae, which, when in position, will be thicker under the phalanges and lateral aspects of the foot, and thinner on the posterior and medial aspects. This will *give the foot the correct tilt in relation to the tube and, with the film placed beneath the wedge, all densities from digits* to tarsus will be similar. The dimensions for such a wedge are shown at **(141)** on page 57.

CENTRE, with the tube straight, over the mid-tarsal region.

(150)

NOTE— When shadowless material is required for radiographic wedges balsa wood should be employed.

DORSI-PLANTAR OBLIQUE (3)

The film may, of course, be placed between wedge and foot, the tube being straight, in which case the wedge may be made of more substantial material, but the varying foot densities will not be corrected.

CENTRE, with the tube straight, over the cuboid-navicular joint.

(151)

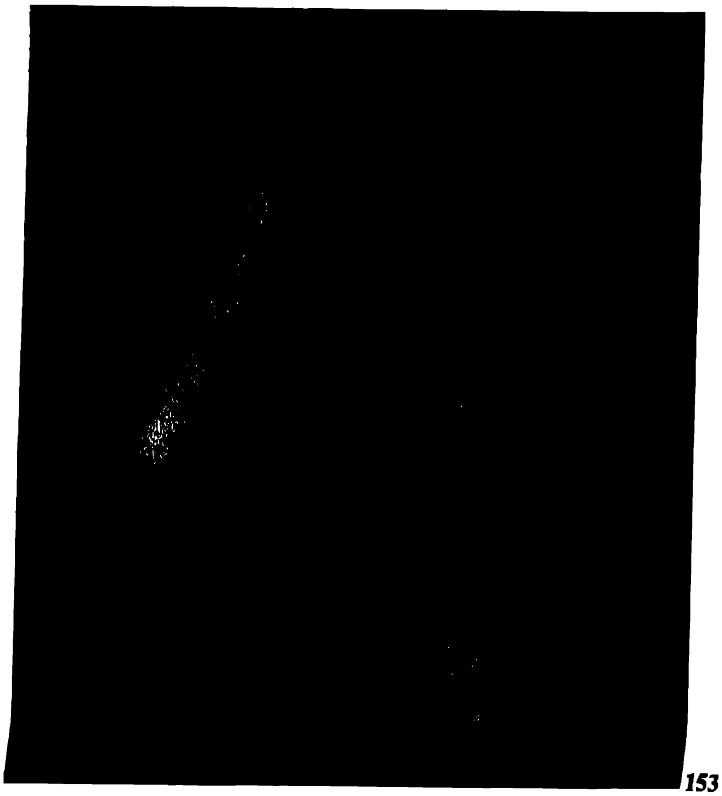
EXPOSURE FACTORS

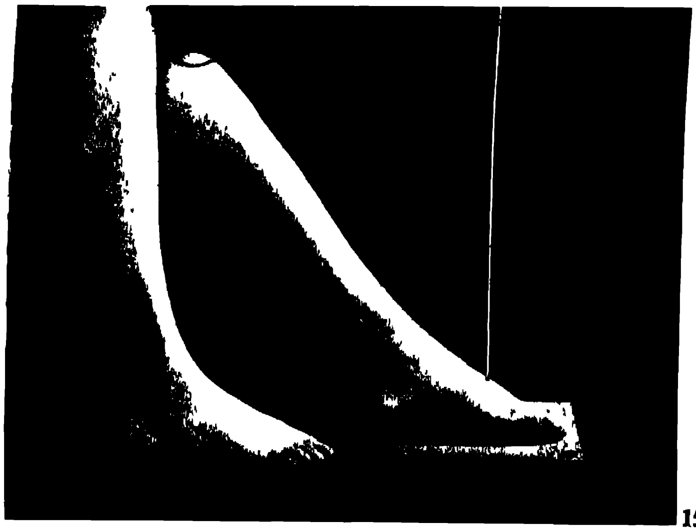
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Ilfex		—
70	26	16	30″	Ilfex	—	-
60	5	3	36″	Ilford	Tungstate	—

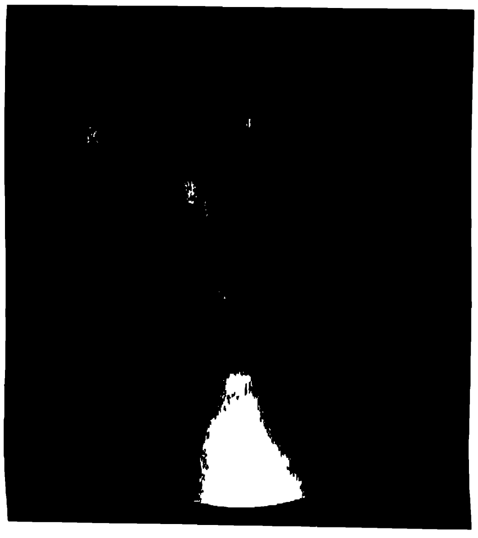
Cone to size of film, 12 × 6 in.

GENERAL NOTE —The radiograph **(149)** shows good separation of the tarsus and metatarsus, with clearly defined tarso-metatarsal articulations.

The illustration **(152)** shows on the left the uniformity resulting from the use of a wedge, as compared with the varying density of the film exposed without the wedge given on the right. These are also typical of the results obtained with high kilovoltage (left) and low kilovoltage (right).


153


154


155

Lower Extremity: Foot

DORSI-PLANTAR

With the patient sitting or semi-recumbent, the foot is placed with the plantar aspect in contact with the film on the flat table, the leg being supported in the vertical position by the other knee.

CENTRE, with the tube straight, over the cuboid-navicular articulation.

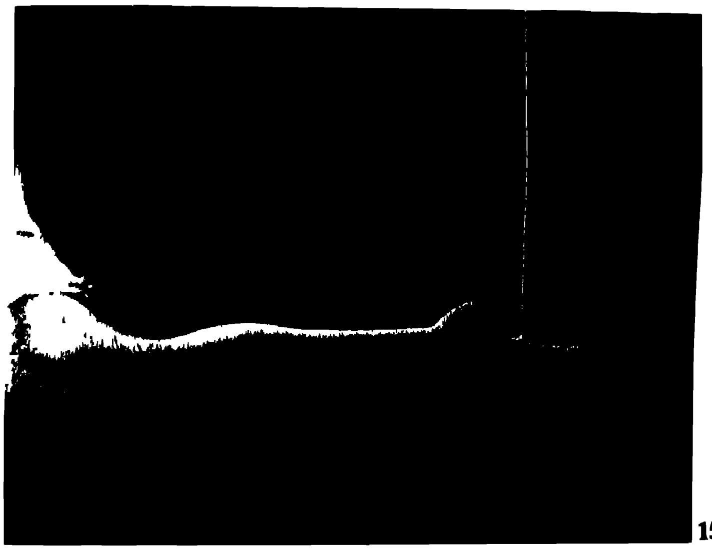
(153, 154, 155)

EXPOSURE FACTORS						
	mA. Secs.					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Ilfex	—	—
70	26	16	30″	Ilfex	—	—
60	5	3	36″	Ilford	Tungstate	—

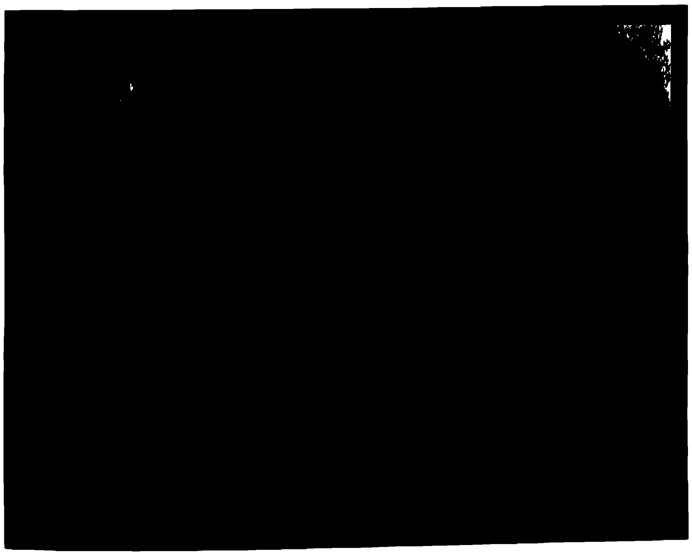
Cone to size of film, 12 · 6 in.

NOTE—This position does not give a good general view of the tarso-metatarsal articulations, as the bones overlap in the direction of the X-ray beam. It is used in conjunction with the true lateral position for the location of foreign bodies and for the great toe, which latter is shown satisfactorily from the tarso-metatarsal articulation.

156



157



158

Lower Extremity: Foot

OBLIQUE

The back rest should be removed and the patient turned over on to the affected side, with the hip and knee joints flexed and the sound limb in contact with the table, and in front of the injured limb. The injured limb is semi-oblique in position, with the lateral aspect of the patella in contact with the table. This position allows the foot to fall obliquely forward.

CENTRE over the base of the fifth metatarsal bone.

(156, 157, 158)

EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers BlueLabel	Distance	Film	Screens Ilford	Grid
60	58	35	30″	Ilfex	—	–
70	31	20	30″	Ilfex	—	–
60	5	3	36″	Ilford	Tungstate	--

Cone to size of film, 12 × 6 in.

NOTE—The metatarsal bones are shown in a slightly oblique position, but clearly separated one from the other, permitting minor injuries to be demonstrated satisfactorily. This separation of the bones by projection is obtained in the same way as for the oblique view of the hand (Diagram 10, page 13).

Lower Extremity: Foot


159

LATERAL

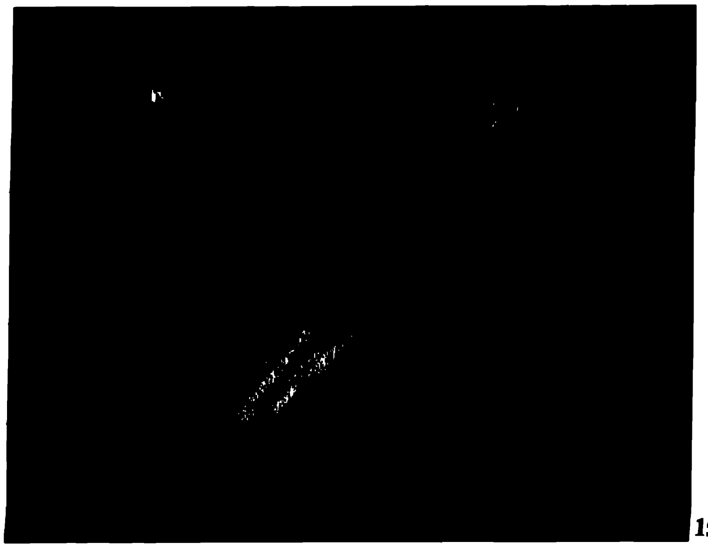
The patient is moved into the general lateral position, with the knees flexed and the good limb raised on sandbags in front of the injured limb. A sandbag is placed under the anterior aspect of the affected knee so that the ankle and foot are tilted backward into the true lateral position, with the plantar aspect of the foot at right-angles to the film. The position of the limb should be compared in photographs (159) and (157), and in the radiographs (159a) and (158).

CENTRE to the mid-tarsal region.

(159, 159a)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	86	52	30″	Ilfex	—	—
70	48	30	30″	Ilfex	—	—
60	8	5	36″	Ilford	Tungstate	--

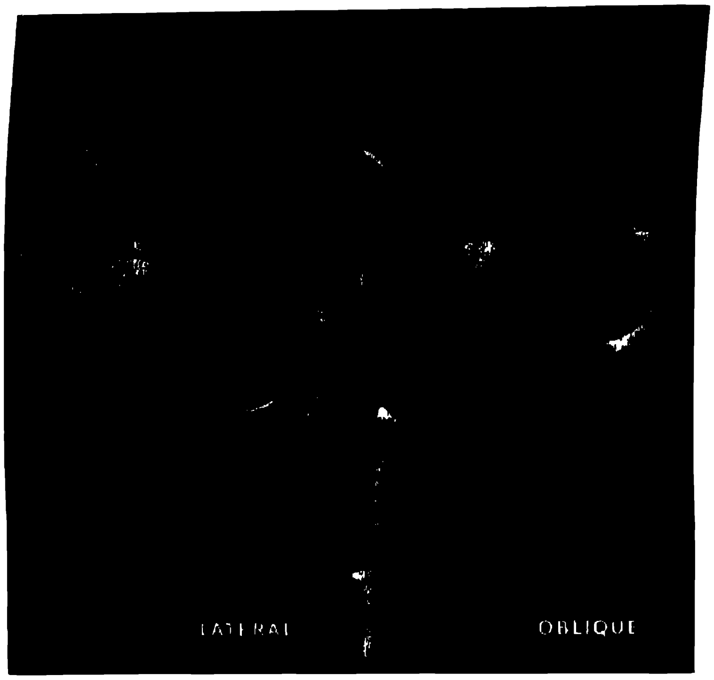
Cone to size of film, 12 × 6 in.


159a

NOTE—*This position gives a true lateral view of the tarsal bones and ankle joint. The five metatarsal bones overshadow each other, so that a minor injury in this region is not always shown, but the position of foreign bodies in all parts of the foot is demonstrated.*

FOOT--GENERAL NOTE

For all pathological conditions both feet are radiographed for comparison, as shown in the radiographs (161, 162, 163), a case of Kohler's disease (osteochondritis). Similar comparative views are frequently required by the orthopædic surgeon to eliminate any question of pathology before manipulative treatment is applied. In these cases the oblique positions are used. Films should be marked carefully to indicate right and left sides.

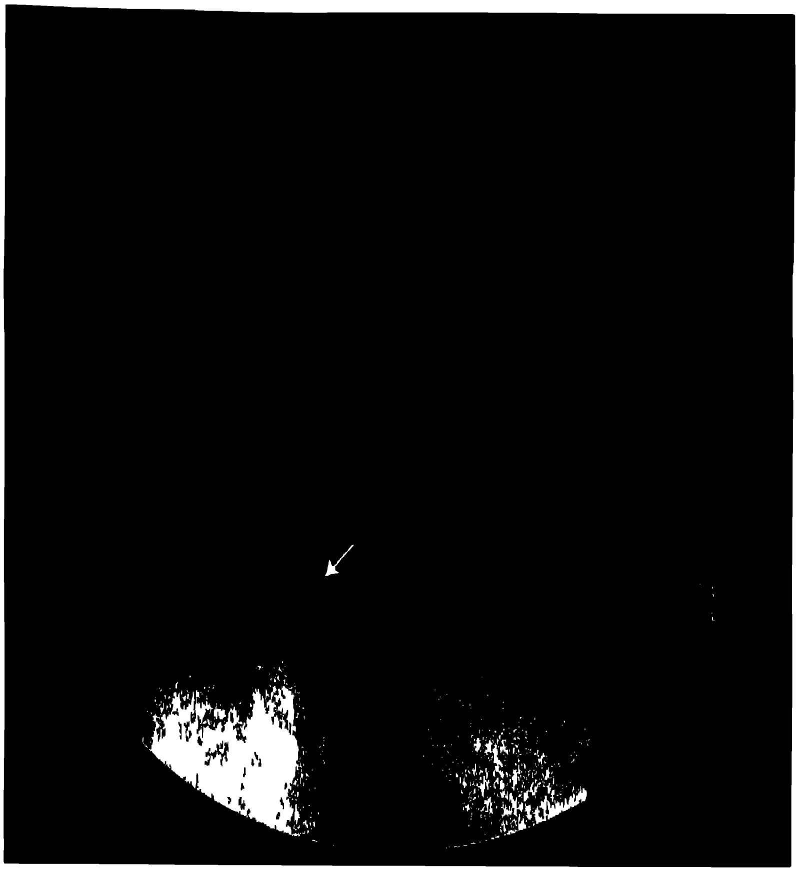


160 160a

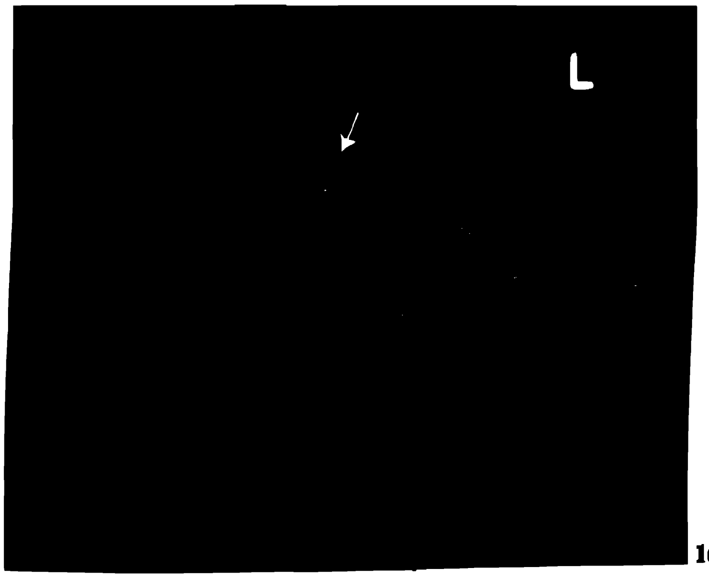
FRACTURE RADIOGRAPHS

The lateral radiograph of the foot (160) fails to disclose a fracture of the calcaneum, but in the oblique view (160a) the shadows of the talus and calcaneum are separated and the fracture becomes visible.

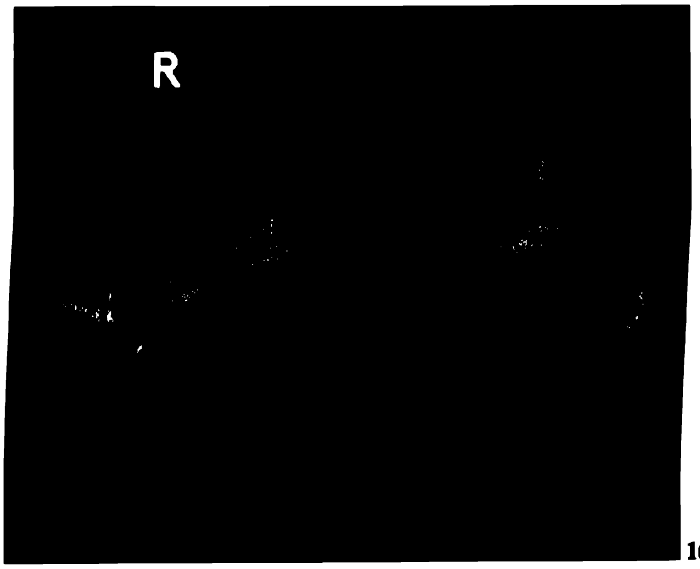
These radiographs serve as still further confirmation of the value of the oblique view.



161



162



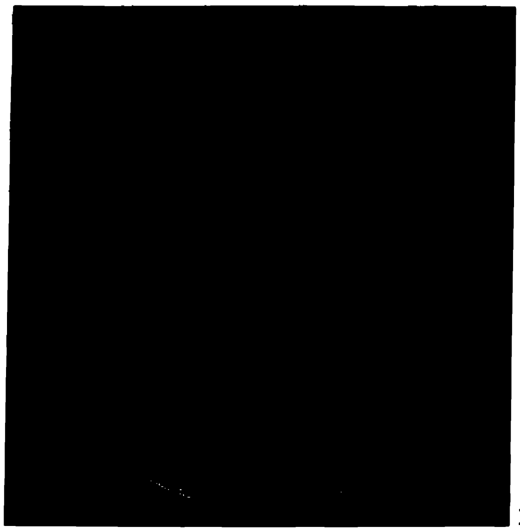
163

Lower Extremity: Toes

LATERAL *(continued)*

Occasionally an additional centre of ossification develops in place of the posterior tubercle of the talus (astragalus), forming a separate bone known as the os trigonum. This fragment of bone may lead to confusion in fracture cases, so that comparative lateral views of the two feet are necessary.

(164)



164

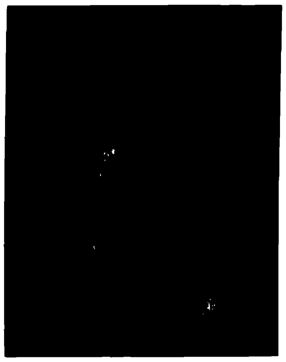
Toes

LATERAL

The toes are so variable in length and direction that the position for the lateral view must be adapted to the requirements of each patient. A dental film between individual toes, with flexion of adjacent toes, may be applied with success, but an occlusal film will be necessary for the phalanges of the great toe.

(165, 165a)

165



165a

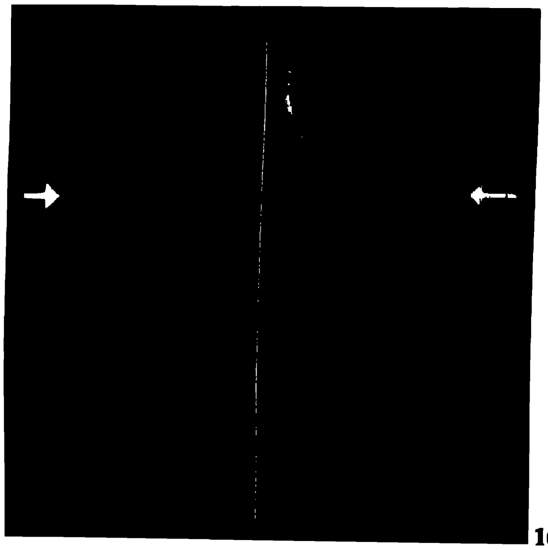
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	16	10	30″	Standard Dental	—	—
60	8	5	30″	Standard Dental	—	—

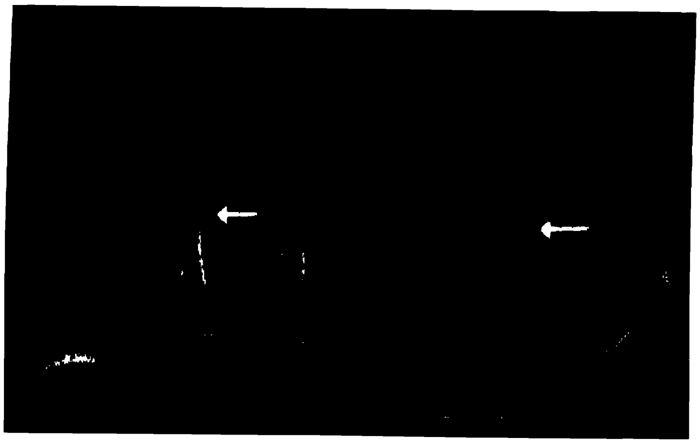
Small cone.

FRACTURE RADIOGRAPHS

In two cases of injury to the toes the dorsi-plantar views might be considered as inconclusive, but all doubt is removed on seeing the lateral view of the proximal phalanx of the little toe **(166)** and of the second toe **(166a)**.

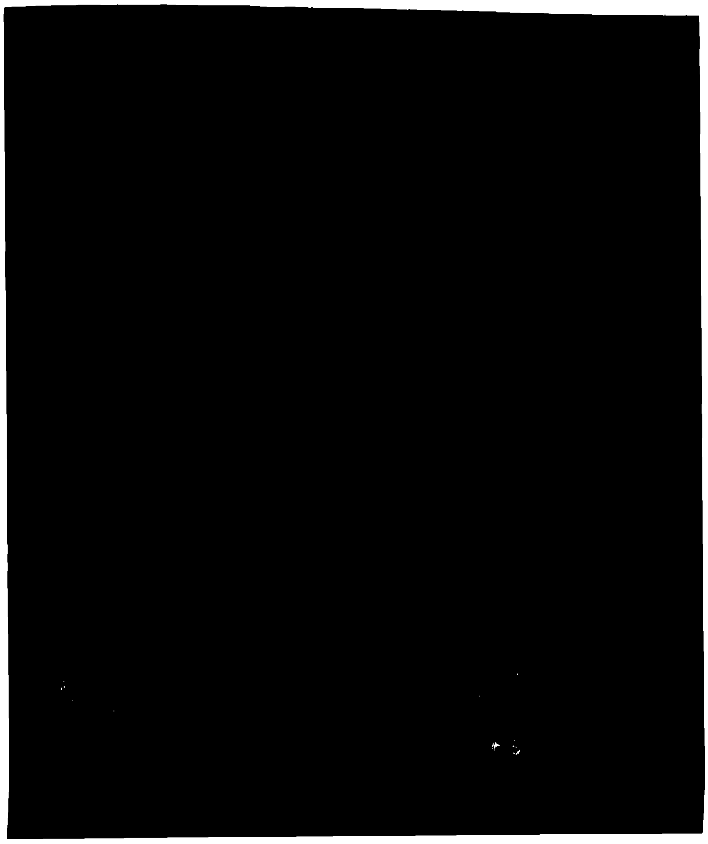


166

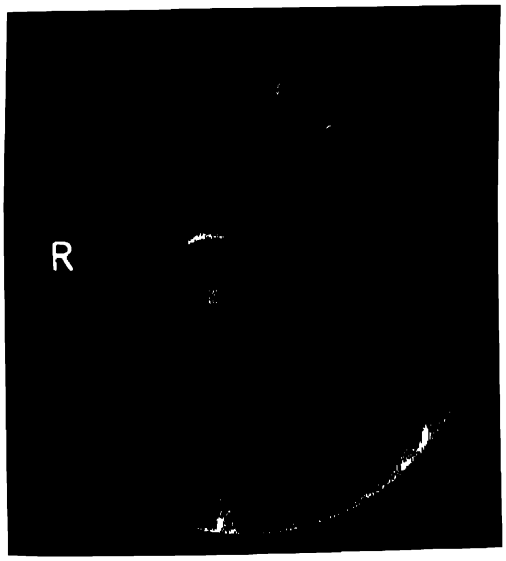


166a

Lower Extremity



167



168

Great Toe

DORSI-PLANTAR

The foot is placed with the plantar aspect in contact with the film, the leg being maintained in the vertical position.

CENTRE over the first metatarso-phalangeal joint.

(167, 168)

EXPOSURE FACTORS

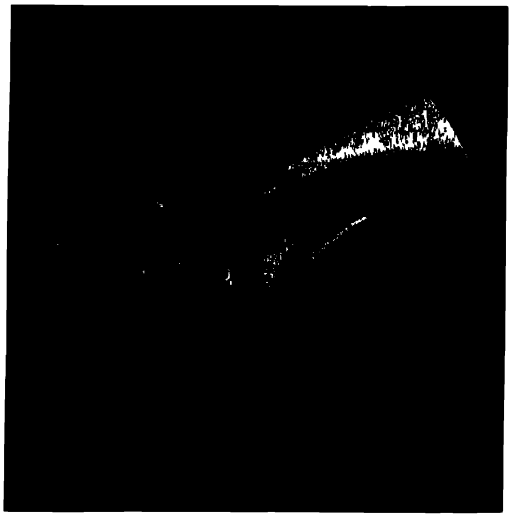
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	40	24	30″	Ilfex	-	—
70	21	13	30″	Ilfex	—	—
60	5	3	40″	Ilford	Tungstate	—

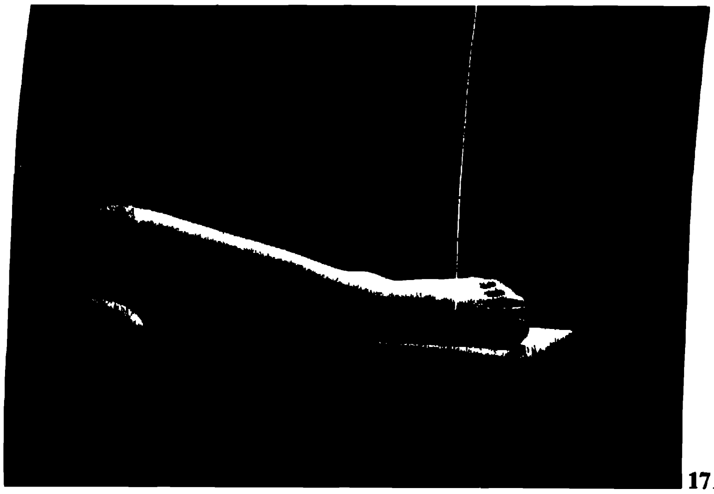
Cone to size of film, 8½ × 6½ in.

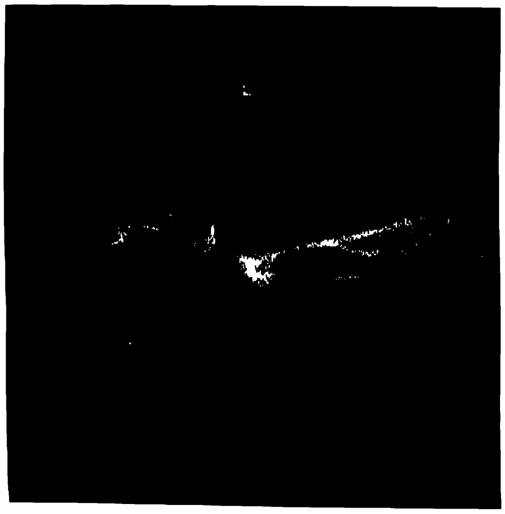
NOTE—When the foot is inverted, as for the dorsi-plantar oblique view, the great toe is partially overshadowed by adjacent bones and is not clearly demonstrated (149).

As there is a considerable difference in the thickness of the toe from the base of the metatarsal bone to the distal phalanx, it is necessary that the kilovoltage should be adjusted to produce a film of such quality that both regions are equally well shown.


169


170


171


172

Lower Extremity: Great Toe

LATERAL (1)

The limb should be placed with the great toe and medial aspect of the leg, including the patella, in contact with the couch. The heel is raised on a sandbag and the film supported in contact with the foot. The sole of the foot is obliquely forward in relation to the film.

CENTRE over the ball of the great toe.

(169, 170)

This position gives the most satisfactory lateral view of the great toe from base of metatarsal bone to terminal phalanx.

LATERAL (2)

Alternatively, the knee is raised on a sandbag and the foot tilted backward so that the sole of the foot is oblique in relation to the film.

CENTRE to the anterior aspect of the first metatarso-phalangeal joint.

(171, 172)

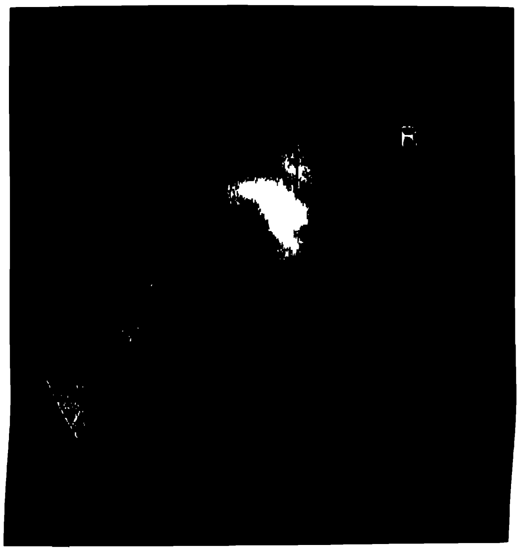
NOTE– The choice of lateral (1) or (2) depends on the patient's ability to maintain the position.

EXPOSURE FACTORS

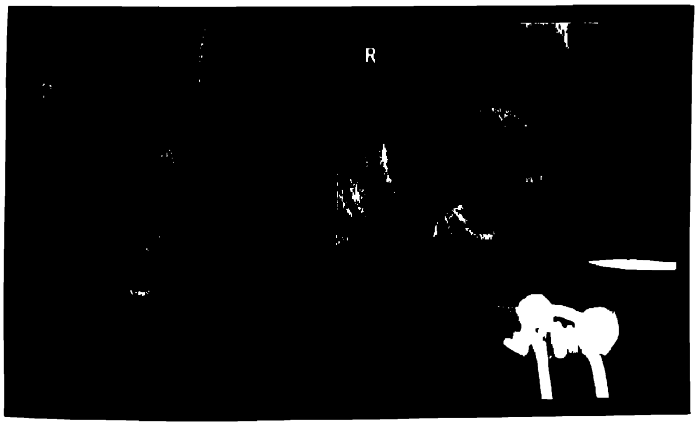
KVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	50	30	30″	Ilfex	—	
70	26	16	30″	Ilfex	—	
60	5	3	36″	Ilford	Tungstate	

Cone to size of film, 8½ × 6½ in.

173



174



174a 174b

Lower Extremity

Calcaneum (Os Calcis)

In radiographing the heel it is most important to take true lateral and axial views, with the tube and film in the correct relationship to the bone in spite of the presence of awkward appliances, although after the first examination elongation of the bone shadow is permissible in the axial view.

Manipulative methods aim at correct alignment between certain bony points, and much depends upon taking the radiographs in the correct position and taking comparative views from one examination to another **(174a, 174b)**.

Lateral and axial views are always taken of both sides for comparison.

There are three methods of taking the axial view, the condition of the patient dictating the one applied.

LATERAL

The limb is placed in the lateral position, with a sandbag under the knee to enable a true lateral view to be obtained.

CENTRE over the articulation between the talus and calcaneum. **(173, 174)**

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	60	36	30″	Ilfex	-	
70	33	20	30″	Ilfex		
60	6	4	40″	Ilford	Tungstate	

Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in.

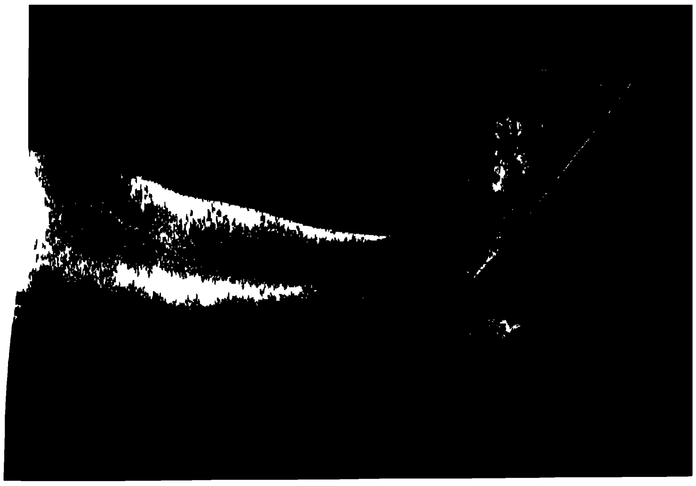
FRACTURE RADIOGRAPHS

The lateral view **(174a)** shows a fracture of the calcaneum with displacement of the fragments and **(174b)** adjustment of the fragments with the traction pin in position.

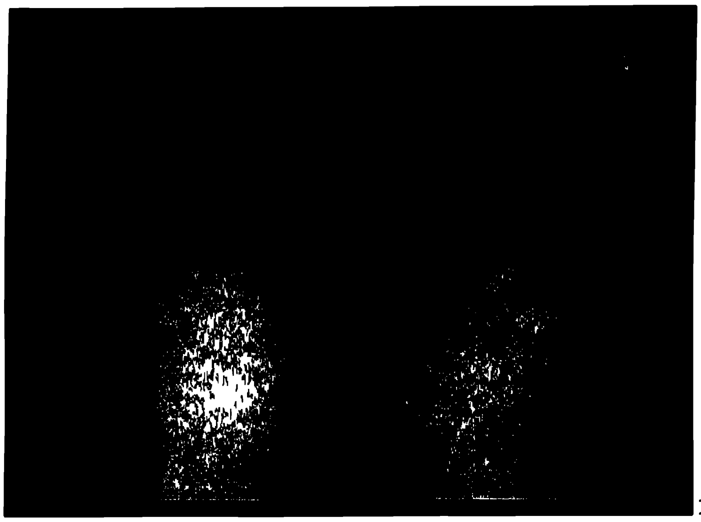
The enlargement of the bones in **(174b)** is due to the distance between heel and film, the appliances being interposed.

OBLIQUE

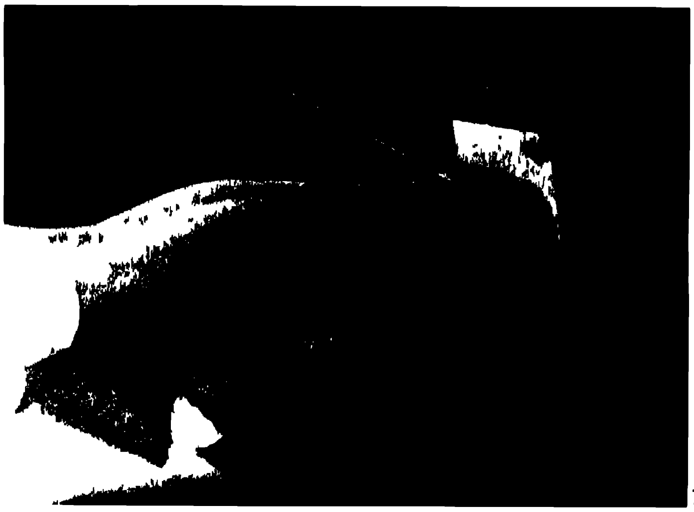
It is also of value to take an oblique view of the calcaneum, especially when the talus-calcaneum region is suspected, as shown in **(160)** lateral and confirmed in **(160a)** oblique. Positioning for the oblique view is shown in **(156, 157)** on page 61.



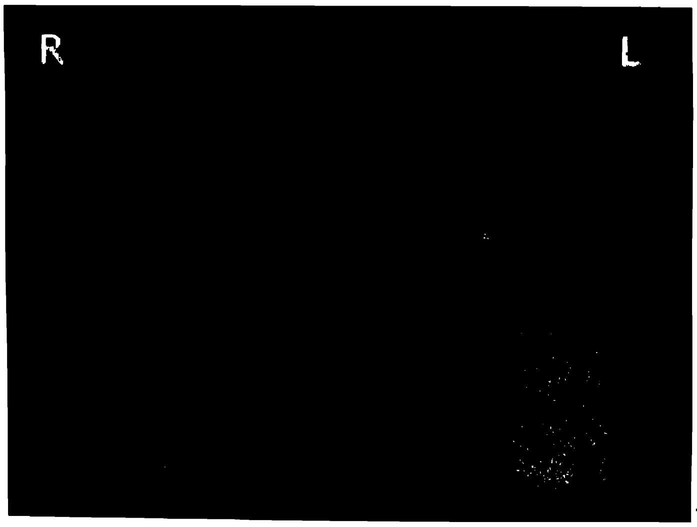
175



176



177



178

Lower Extremity: Calcaneum (Os Calcis)

AXIAL (1)

The patient is sitting or recumbent, with the limbs in the antero-posterior position and the knees slightly raised over a sandbag. The heels are separated by a small cotton-wool pad, and the great toes are in contact with each other. The film is placed under the back of the heels.

CENTRE to the plantar aspect of the heels, with the tube angled at 40 degrees toward and between the heels.

(175, 176)

EXPOSURE FACTORS						
	mA Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	148	90	30″	Ilfex		
70	10	6	30″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in.

NOTE—This is the most suitable position of an injured limb for ward and theatre work before, during, and after manipulative treatment.

AXIAL (2)

The patient is raised on pillows, in the prone position, with the plantar aspect of the soles of the feet in contact with the film, which is supported in the vertical position; or, if a convenient vertical film support is available, the feet are allowed to hang over the end of the couch, the film being pressed against the soles.

CENTRE between the posterior aspect of the heels, with the tube angled 60 degrees from the vertical.

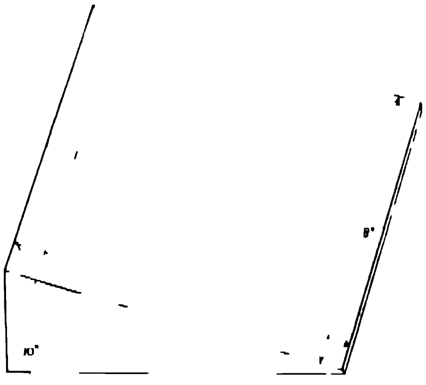
(177, 178)

Lower Extremity: Calcaneum (Os Calcis)

179

AXIAL (3)

With the patient standing with both heels on the film, the body is allowed to lean forward with the knees flexed. A table or chair gives the necessary support to the trunk in this position. If the patient is unable to press the heels down in this manner, a small 15 degrees angle block is placed under the film **(179, 180)**.



180

CENTRE between the heels, with the tube angled at from 10 degrees to 15 degrees from the vertical.

(178, 179)

The tube may be angled at 30 degrees toward the heels to compensate for the patient's inability to flex the knees in this position.

(179a)

It is usually necessary to increase the anode-film distance unless a shock-free tube is available.

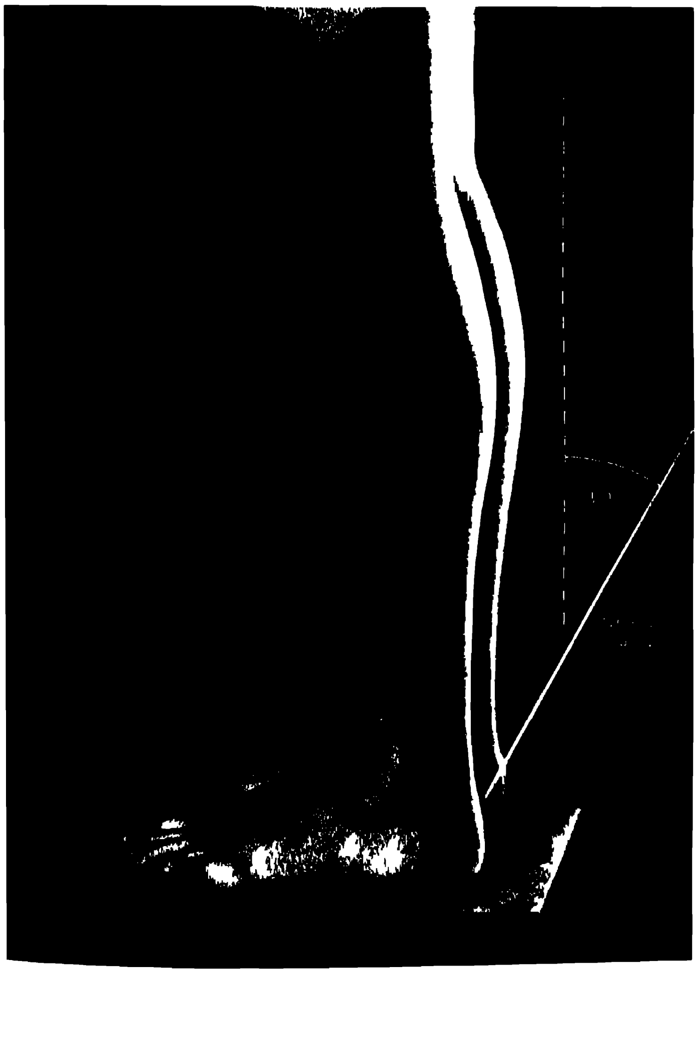
EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	148	90	42″	Ilfex	-	–
70	10	6	42″	Ilford	Tungstate	—

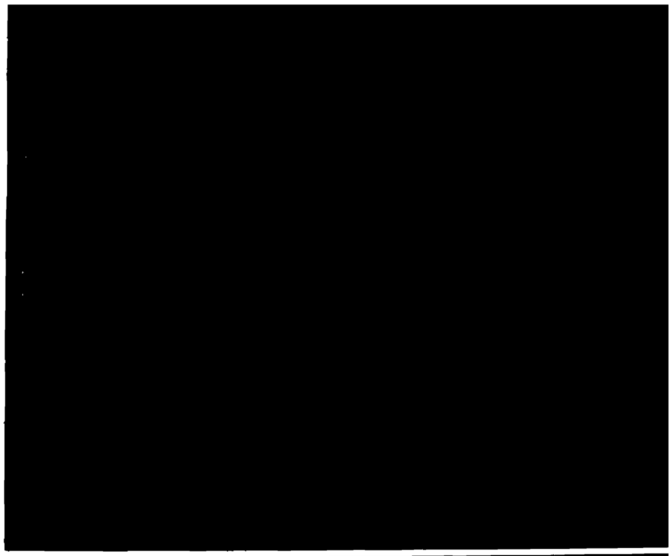
Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in.

NOTE—The result is the same as obtained in axial (2) radiograph **(178)**.

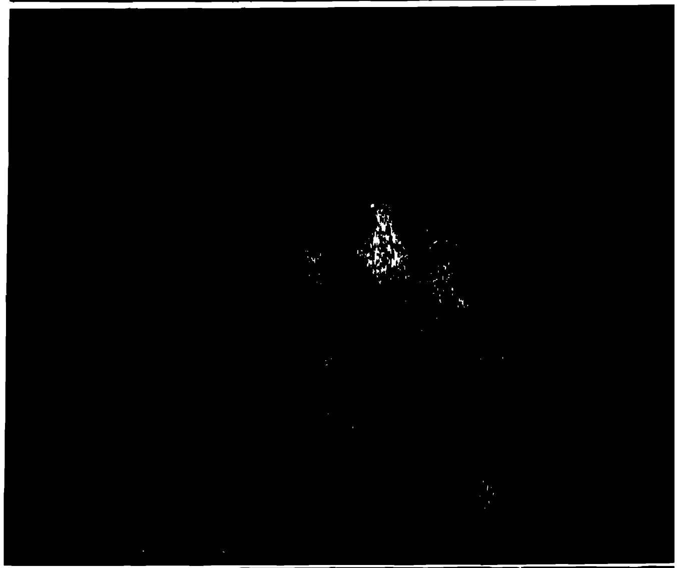
Less exposure is required for axials (2) and (3) than for axial (1), but, with a compensating increase of 12 inches in the anode-film distance, other factors remain the same. The diagram **(180)** gives the dimensions of the angle block used in **(179)**.



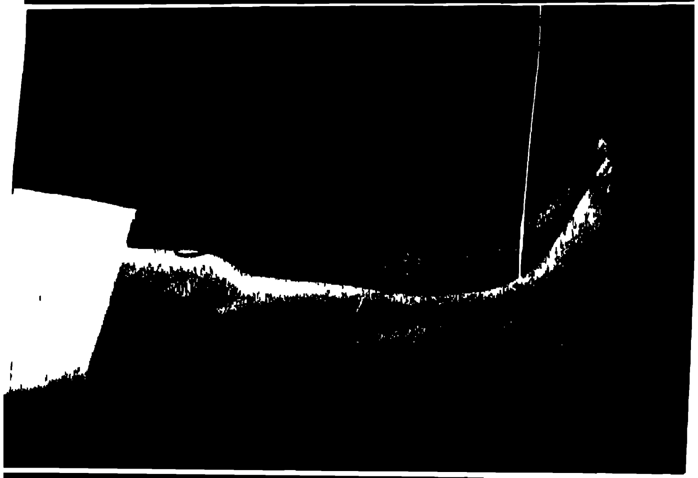
179a

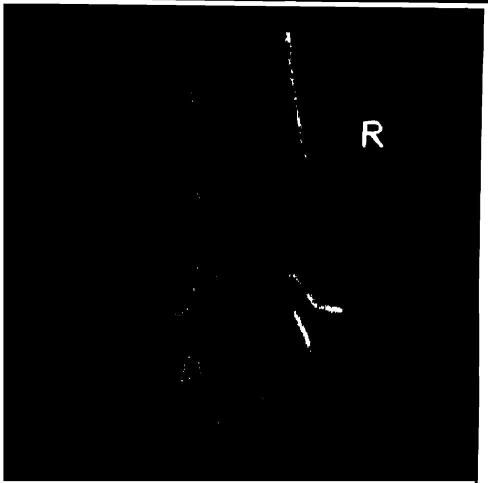


181



181a





183

Lower Extremity: Ankle Joint

FRACTURE RADIOGRAPHS

A crush fracture is shown in these two views of the calcaneum, lateral **(181)** and axial **(181a)**. The latter should always be included in the examination and, as discussed previously, any one of the three methods described will serve to show the alignment of the fragments.

Ankle Joint

ANTERO-POSTERIOR

The patient should be supine or sitting with a back-rest support and with a small sandbag under the knees to allow slight flexion for comfort. A non-opaque pad under the heels serves to prevent discomfort due to pressure of the heels on the couch. Although relaxed, the ankle is supported in flexion, and the leg and foot are slightly rotated medially to bring the malleoli equidistant from the film, thus ensuring a clear joint space in the radiograph between tibia, fibula and talus.

NOTE—The foot is placed so that the joint space is one-third of the film length above the lower border of the film, as it is more important to include the lower third of the leg than the region distal from the malleoli **(188a)**.

CENTRE midway between the malleoli.

(182, 183)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	84	50	30″	Ilfex	—	—
70	46	28	30″	Ilfex	—	--
60	8	5	36″	Ilford	Tungstate	—

Cone to size of film, 4¾ × 6½ in.

Lower Extremity: Ankle Joint

ANTERO-POSTERIOR *(continued)*

The photograph of the soles of the feet (**184**) shows the method of centring according to the position of the foot. The right foot is straight, with the tube angled to bisect the line between the malleoli at right-angles. The left foot is rotated medially, so that the inter-malleolar line is parallel to the film, and the tube is straight.

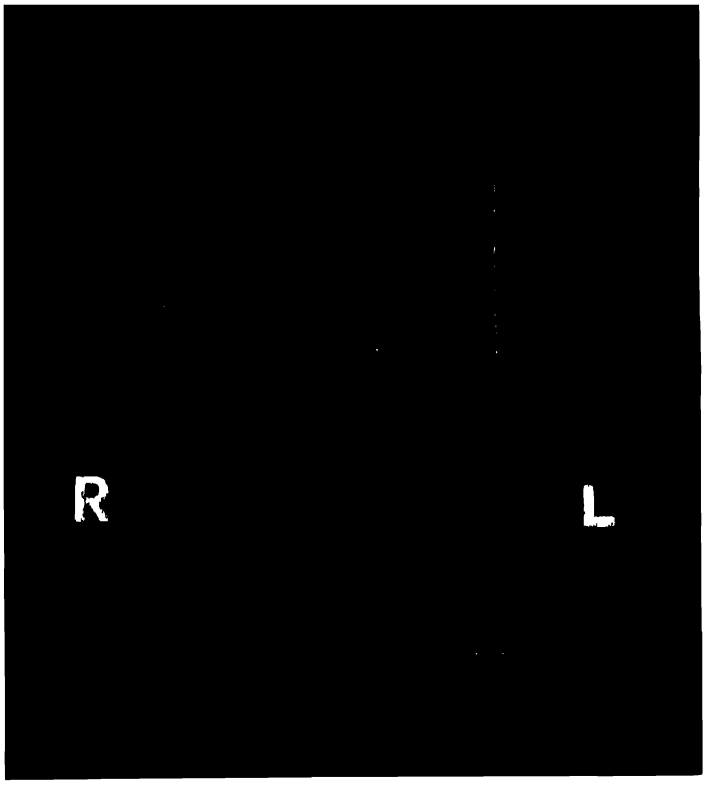
The angle block illustrated on page 69 may be used to steady the feet in position for (**182**), for which purpose it should be placed on end, with the vertical surface toward the soles of the feet, and be maintained in position with sandbags.

INJURIES

When the foot is badly placed on a splint it will be necessary to angle the tube so that the normal ray bisects a line between the malleoli at right-angles in order to obtain a true antero-posterior view. It is usually necessary to angle the tube toward the median line (**185**).

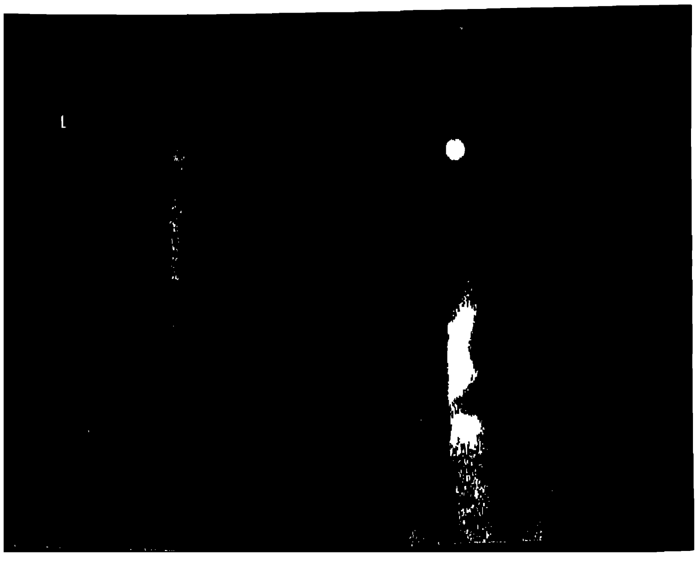
Radiograph (**186**) shows the possible variation in the appearance of the fracture from the antero-posterior aspect, due to the position of the limb in relation to the tube. On the left the leg is rotated outward, with the tube straight, giving a distorted view from the antero-posterior aspect. On the right the tube has been angled medially, as shown in (**185**), to give a true antero-posterior view.

An appearance of subluxation of the ankle joint may be due to rupture or stretching of the tibio-fibular ligaments and is not always illustrated with certainty in the routine antero-posterior view (**183**), but this condition may be confirmed by inverting the foot, as shown in (**186a**). The appearance of the normal ankle joint is shown in a similar position (**186b**), which illustration is included for comparison.



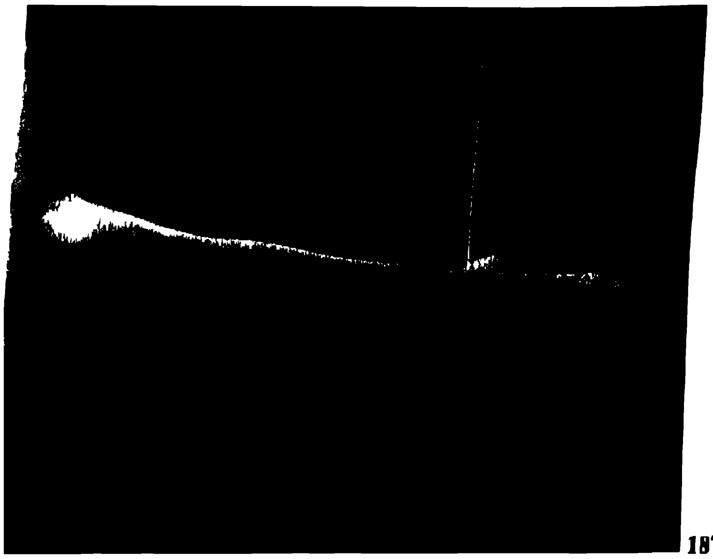
184

185



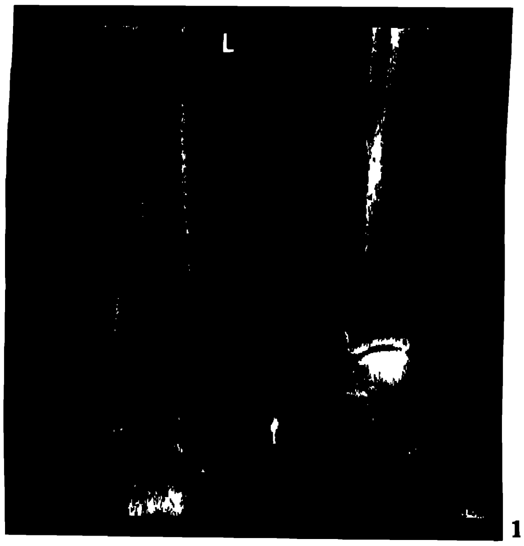
186

186a **186b**



187

188



188a

Lower Extremity: Ankle Joint

LATERAL

The patient is placed in the general lateral position, on the injured side, with a small pad under the anterior aspect of the knee to tilt the ankle into the true lateral position.

In placing the film the lower border should be adjusted to half an inch above the soft tissue outline of the sole of the foot in order to include the maximum length of bone above the ankle joint. This is important in injuries such as a Pott's fracture, when it is necessary to show the general alignment of the bones. It is frequently necessary, without moving the patient, to adjust the tube so that the X-ray beam is projected horizontally, as shown in **(194)**.

CENTRE over the medial malleolus.

(187, 188)

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	60	36	30″	Ilfex		
70	33	20	30″	Ilfex		
60	6	4	40″	Ilford	Tungstate	

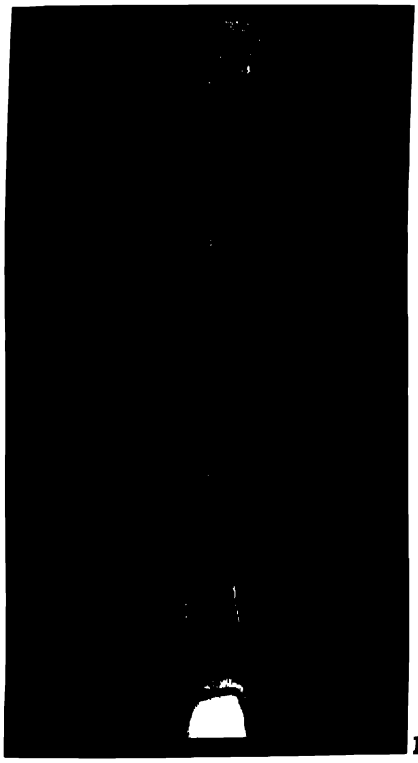
Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in. or $6\frac{1}{2} \times 4\frac{3}{4}$ in.

NOTE—The film should include the lower third of the tibia and fibula, also the talus and calcaneum. The ankle joint space is overshadowed by the malleoli.

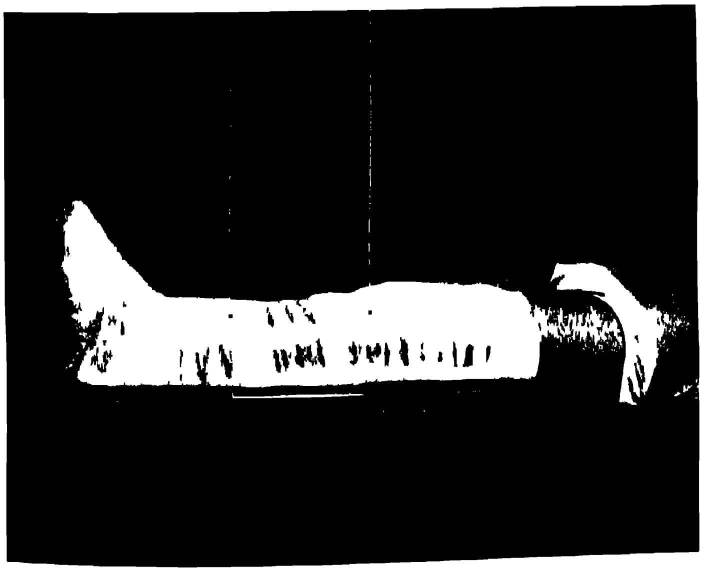
FRACTURE RADIOGRAPHS

The two radiographs shown in illustration **(188a)** indicate the necessity for the inclusion of sufficient area of leg to cover a possible spiral fracture. Every *initial* investigation, indeed, should be regarded as of an exploratory nature, and when the extent of the injury is known the *follow up* examinations may be restricted, within suitable limits, to the affected area.

189



190



191

Lower Extremity

Leg

Gross injuries to the leg require the maximum size of film available to include both knee and ankle joint. Only a short limb can be included on a single film from each aspect, as shown in **(190)** and **(193)**. Extensive dressings and splints may add to the difficulty of locating the site of injury, necessitating two films from each aspect, one from the knee downward and the other from the ankle upward, to include the middle third of the leg on each film, as shown in **(191)** and **(194)**, so that the general alignment of the bone fragments may be seen.

The films should be placed well above the knee joint and well below the ankle joint, or the great divergence of the peripheral radiation will project the joint beyond the film position.

In the case of a gross injury to the lower leg, the proximal tibio-fibula articulation should always be included, as this may be an additional site of injury.

ANTERO-POSTERIOR

The patient should be supine, with the leg slightly rotated medially and supported in position. When the extent of the injury does not necessitate the whole of the leg being included, the film should be placed to cover the joint nearest the site of injury—well below or above the joint to allow for projection distortion.

CENTRE to the middle of the film.

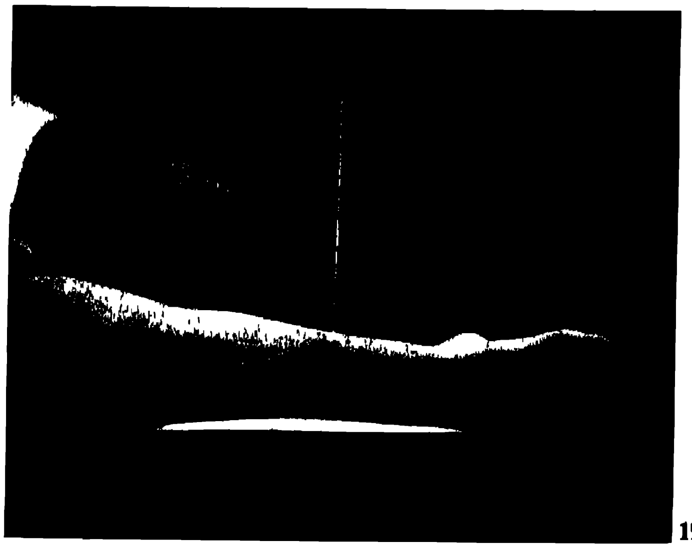
(189, 190)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray Upper	X-ray Lower	Blue Label Upper	Blue Label Lower	Distance	Film	Screens Ilford
60	132	84	80	51	30″	Ilfex	—
60	13	8	8	5	36″	Ilford	Tungstate

Film, 15 × 6 in. or 17 × 7 in.

Lower Extremity: Leg



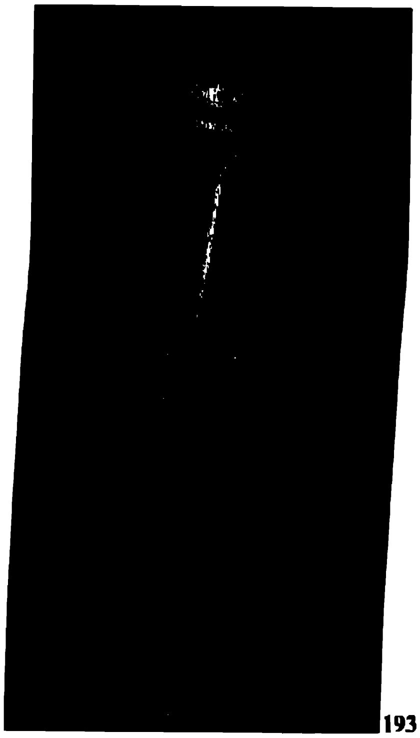
192

LATERAL

The patient is turned on to the affected side, with the limb generally in the true lateral position. The film is placed to include the joint adjacent to the site of injury, or the whole leg is included on two films.

CENTRE to the middle of the film.

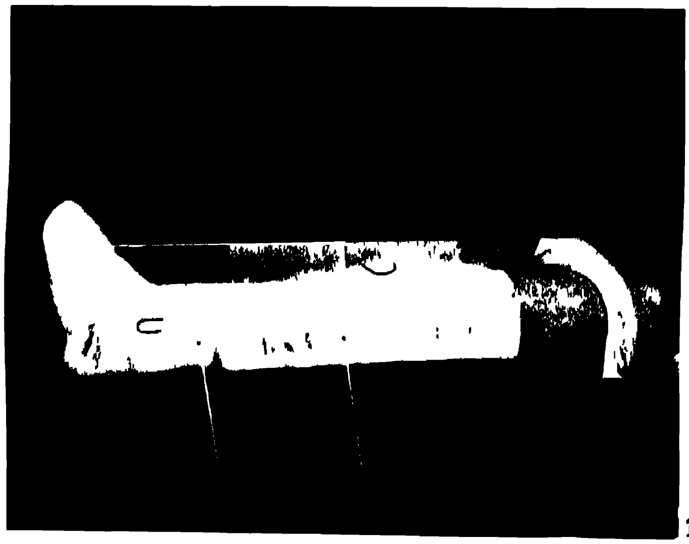
(192, 193)



193

STRETCHER PATIENTS

Apart from causing the patient unnecessary discomfort, it is not always advisable to move the limb into the lateral position, and in such cases it is preferable to maintain the supine position throughout the examination. After exposing for the antero-posterior position the ward mobile unit is adjusted to direct the beam horizontally toward the lateral aspect of the leg (194).



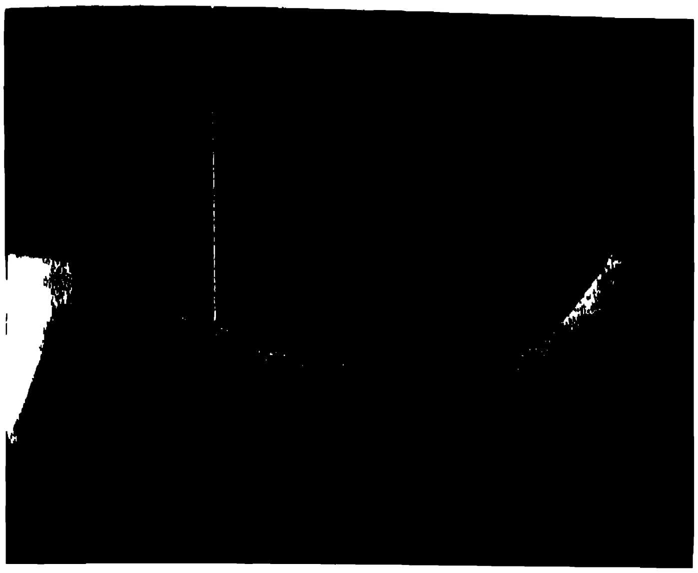
194

EXPOSURE FACTORS

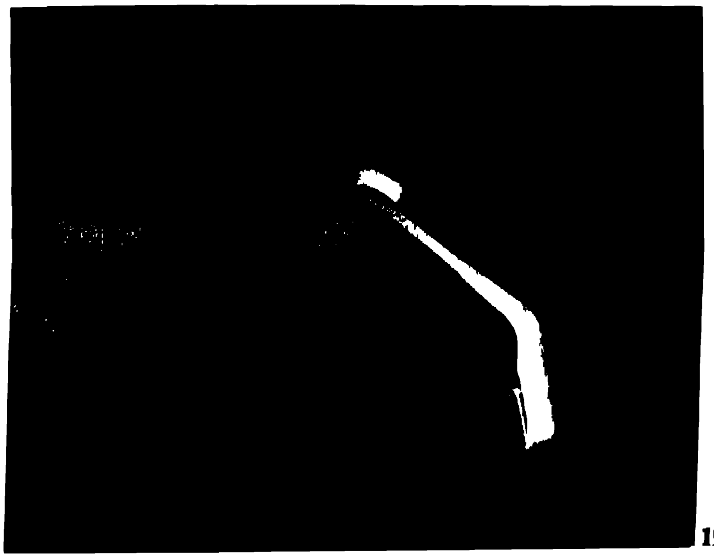
kVp.	mA. Secs. Ilford Developers X-ray Upper	X-ray Lower	Blue Label Upper	Blue Label Lower	Distance	Film	Screens Ilford
60	100	60	60	36	30"	Ilfex	
60	10	6	6	4	36"	Ilford	Tungstate

Film, 15 × 6 in. or 17 × 7 in.

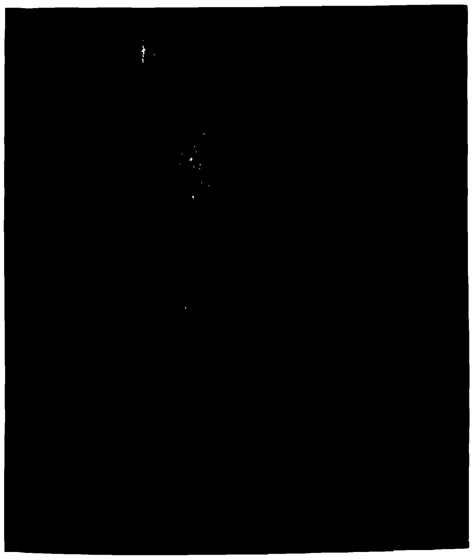
Lower Extremity



195



196



197

Knee Joint

The knee joint, including soft structures, is frequently examined for minor abnormalities, both pathological and traumatic, in addition to gross conditions. The anatomy of the joint should be fully appreciated before the radiographic examination is attempted.

The choice of screened or unscreened films is a matter for the individual worker to decide.

ANTERO-POSTERIOR

With the patient supine or sitting supported by a back rest, the knee is relaxed. When necessary, the film is supported on a small sandbag to bring it into close contact with the posterior aspect of the knee. It may be necessary to rotate the leg slightly outward to centralise the patella over the joint, the limb being held in position by sandbags, or by the use of a bandage twisted round the foot and having equally weighted ends hanging over the side of the couch (196). This simple device allows the limb to be adjusted to the correct position and then acts as an immobiliser.

CENTRE half an inch below the lower border of the patella.

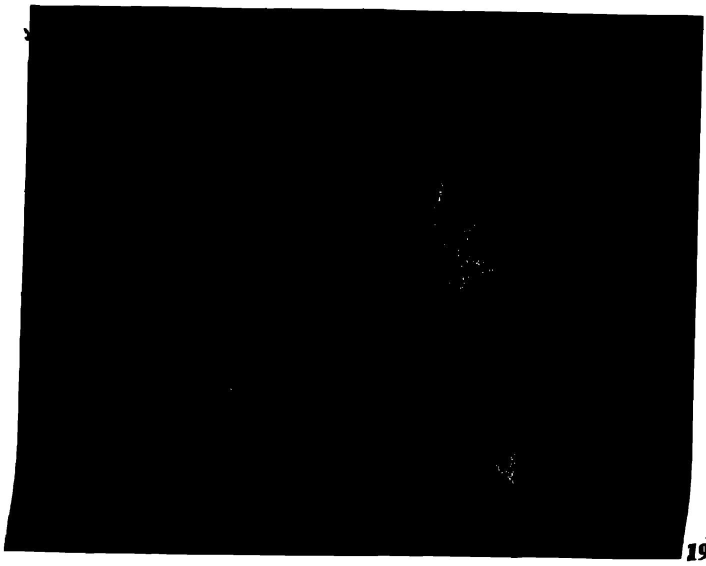
(195, 197)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	132	80	30″	Ilfex	—	-
50	26	16	36″	Ilford	Tungstate	—
60	13	8	36″	Ilford	Tungstate	—

Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in.

NOTE—When intensifying screens are used the flat cassette cannot be placed in close contact with the knee unless the knee is fully extended, but by increasing the anode-film distance loss of definition is avoided. In the absence of splints or plaster the use of the curved cassette allows approximation of the film to the knee and encourages comfortable relaxation of the limb, which in turn assists immobilisation.



198

Lower Extremity: Knee Joint

ANTERO-POSTERIOR *(continued)*

INJURIES

Difficulties due to splinting may be overcome by angling the tube in order to obtain true antero-posterior or lateral views, as may be required (198).

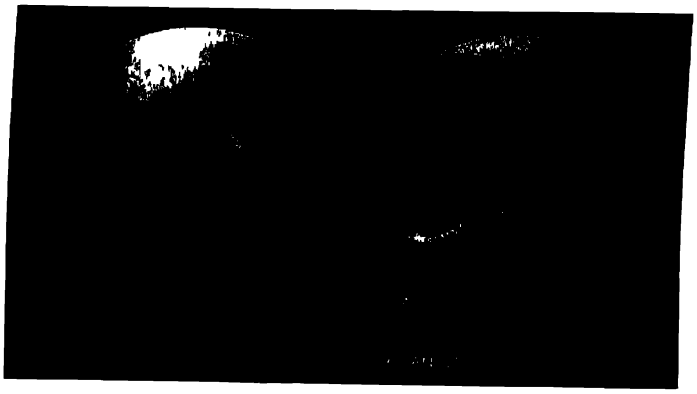
INTERCONDYLOID NOTCH

To show the femoral intercondyloid notch the limb should be allowed to relax so that the knee may be slightly flexed over the cassette, which is raised on a small sandbag and placed well up under the femur (198a). Close contact of the film with the limb may be obtained by employing a curved cassette or a double wrapped film bent to the shape of the knee.

Centre immediately below the lower border of the patella with the tube angled toward the knee and the axial ray directed

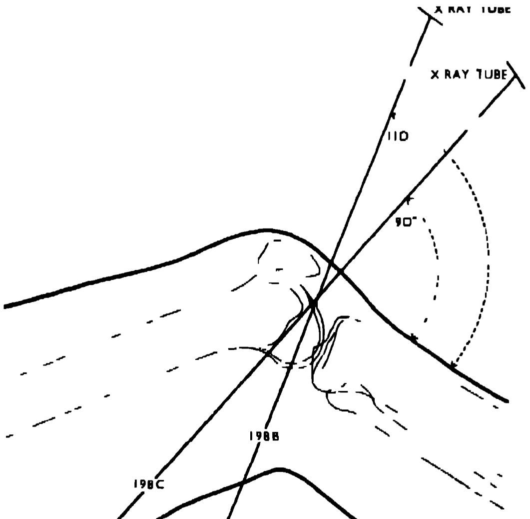
(a) at 110 degrees to the leg to show the *anterior* portion of the intercondyloid notch (198b); and

(b) at 90 degrees to the leg to show the *posterior* margin of the notch (198c).



198b 198c

(198a, 198b, 198c)



198a

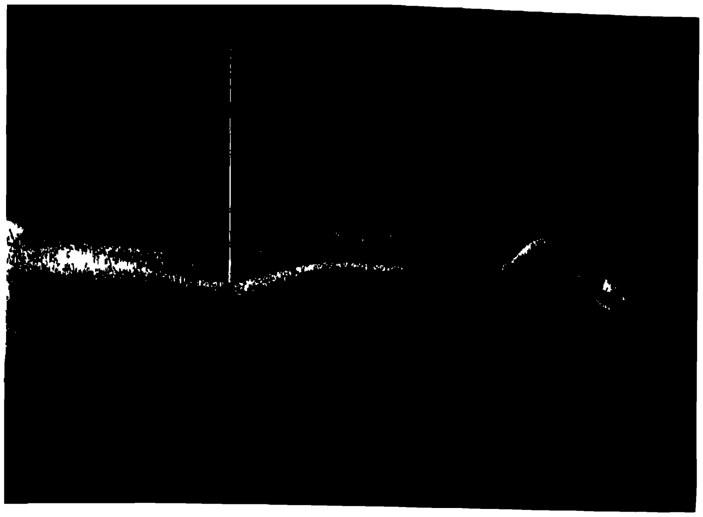
199

SEMILUNAR CARTILAGE

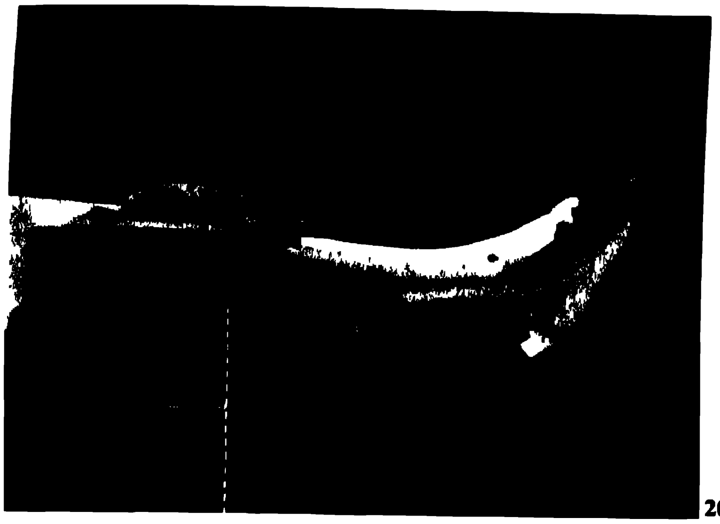
For a slipped semilunar cartilage, in addition to the bone films it is necessary to take antero-posterior and lateral views of both knees to show the soft structures. To produce the density as shown in (199) and (200) the normal knee exposure time is reduced by 50 per cent.

See also Pneumoarthrography, pages 83 and 84.

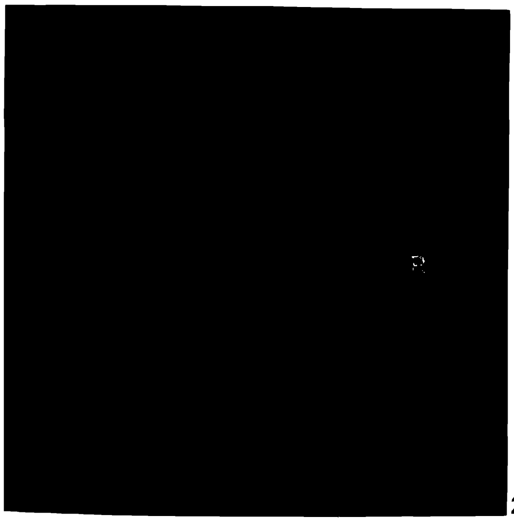
200



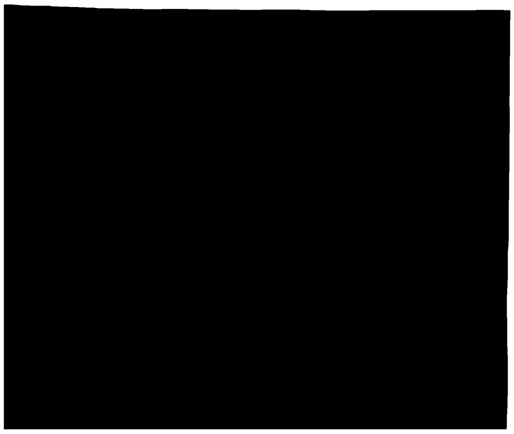
201



202



203



Lower Extremity: Knee Joint

POSTERO-ANTERIOR (1)

This position is used when an injury to the patella is in question. Close contact with the film gives a sharply defined image, such as cannot be obtained from the antero-posterior aspect. Postero-anterior view (**203**) should be compared with antero-posterior view (**204**). An increase of 75 per cent. on the antero-posterior knee exposure time is essential to show bone detail in the patella. Radiograph (**203**) should be compared with radiograph (**197**).

With the patient in the prone position the knee is slightly flexed by placing a small sandbag beneath the leg and thigh, thus preventing uncomfortable pressure of the patella on the couch; in addition, a sandbag under the ankle joint raises the toes and adds greatly to the patient's comfort.

CENTRE to the crease of the knee.

(**201, 203**)

NOTE—It is rarely possible to apply this position to an injured knee, but the same result may be obtained without discomfort to the patient by using the under-couch tube.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	230	140	30″	Ilfex	—	—
50	46	28	36″	Ilford	Tungstate	—
60	23	14	36″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 6½ × 8½ in.

POSTERO-ANTERIOR (2)

With the patient supine, and with a small non-opaque pad under the knee for comfort, the film is placed on the anterior aspect of the knee and supported in position by wood blocks or the Finzi plate-holder, a small sandbag being placed on the film to maintain it in position. It may be necessary to rotate the leg slightly outward to centralise the patella over the femur.

CENTRE half an inch below the patella, using the under-couch tube.

(**202, 203**)

Lower Extremity: Knee Joint

205

INFRA-SUPERIOR

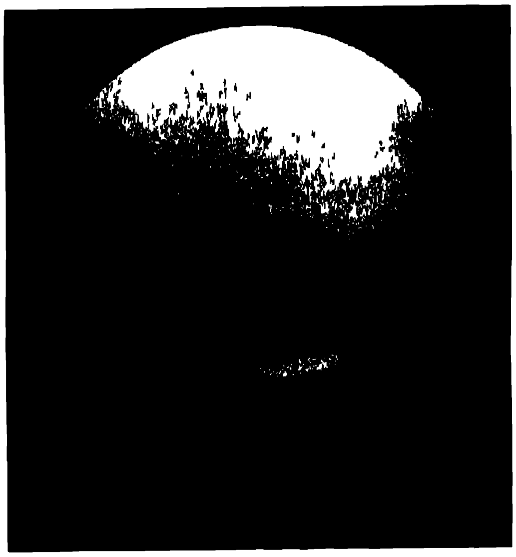
The patient is placed in the prone position, with right-angle flexion at the knee joint. The limb is steadied by a bandage tied to the foot and attached at the other end to a vertical support.

CENTRE behind the patella, with the tube angled approximately 15 degrees toward the knee, to avoid the toes. **(205, 206)**

NOTE—This is not a routine position, but may be used to advantage when information is required concerning the adjacent surfaces of the patella and femur.

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	132	80	30″	Ilfex	—	—
60	13	8	36″	Ilford	Tungstate	—

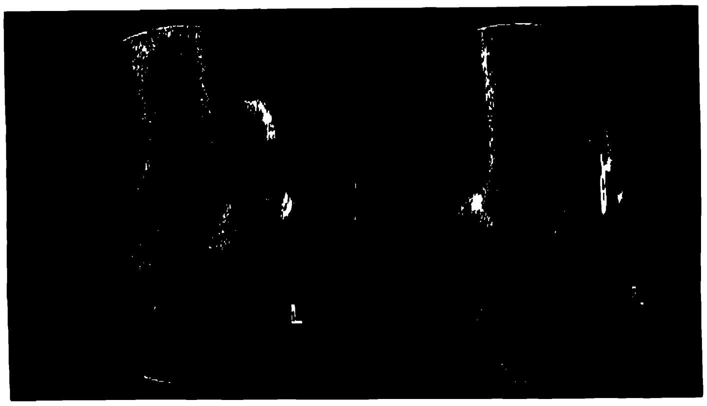
Cone to size of film, 6½ × 4¾ in.



206

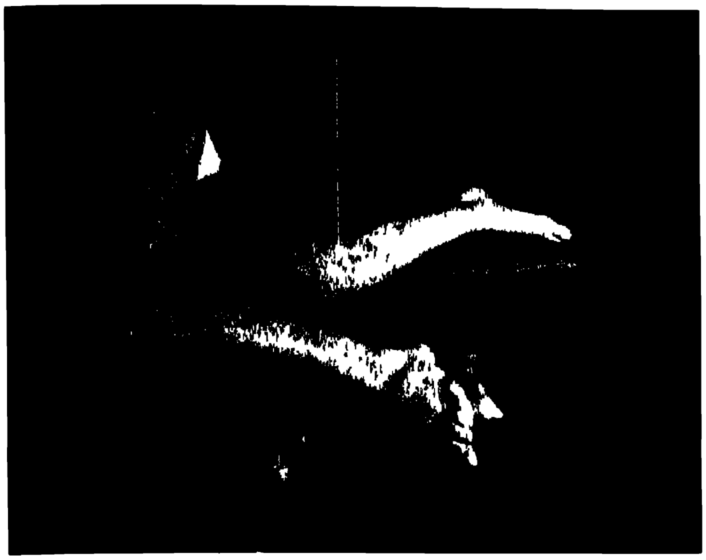
FRACTURE RADIOGRAPHS

For the examination of the patella the lateral view described on the next page is of major importance, as indicated by the two radiographs of a fractured patella **(206a)**, one taken before and one after treatment.



206a

Lower Extremity: Knee Joint



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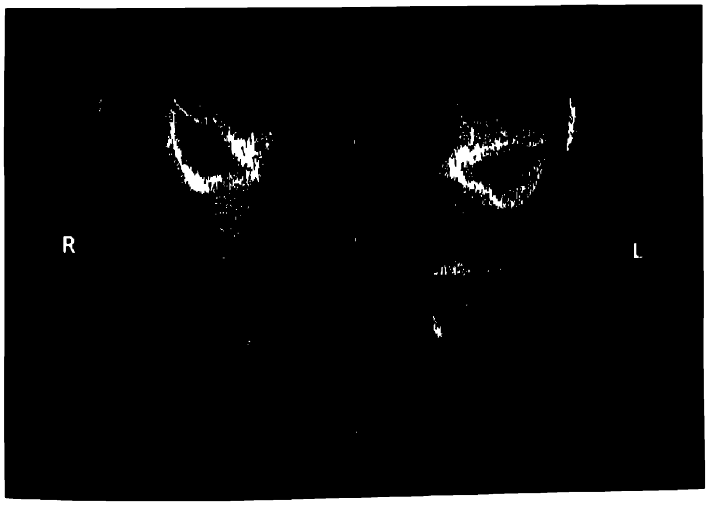


210

LATERAL

Failure to obtain true lateral views may be due to the fact that the operator may not appreciate the general relationship of the bones and articular surfaces entering into the joint. When the subject is erect the femur is oblique in direction from hip to knee joint, lateral to medial. Since the articular surfaces of the knee joint are horizontal, they are not at right-angles to the shaft of the femur (**207**). This fact should be taken into consideration, as also should the general plane of the joint and the position of the patella when the limb is placed in the lateral position.

207

The patient is turned on to the affected side, with the limb flexed at hip and knee joints and the sound leg brought well forward to rest on the couch in front of the injured limb. The ankle of the injured side is raised on a small sandbag to bring the long axis of the tibia parallel to the film.

CENTRE over the medial tuberosity of the tibia, which can be felt as a prominent ridge approximately one inch below and medial to the lower border of the patella when the knee is flexed. **(208, 209)**

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	100	60	30″	Ilfex	—	
50	20	12	36″	Ilford	Tungstate	—
60	10	6	36″	Ilford	Tungstate	

Cone to size of film, 8½ × 6½ in.

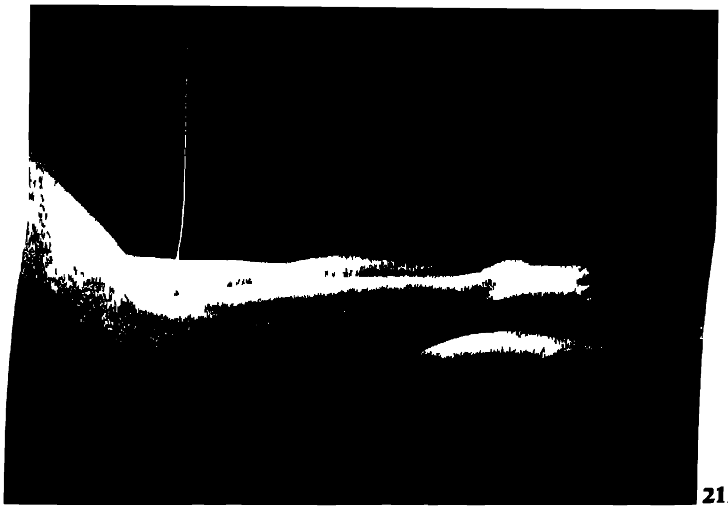
For stretcher cases the same technique is employed as for the lower leg (**194**), so that painful manipulation of the limb is avoided (**206a**).

TIBIAL TUBERCLE

In disease affecting the tibial tubercle, lateral views are taken of both limbs to include tibial tubercle and knee joint.

CENTRE over the tibial tubercle.

(210)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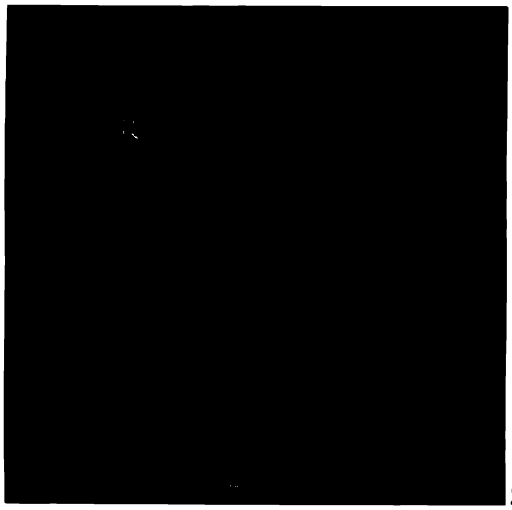
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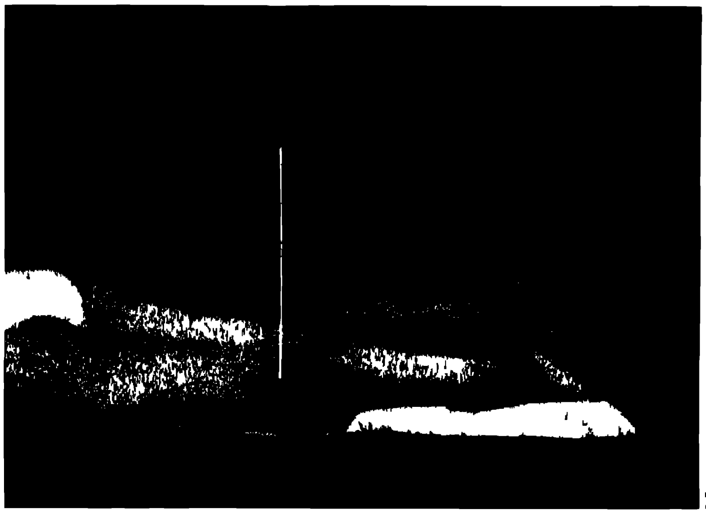
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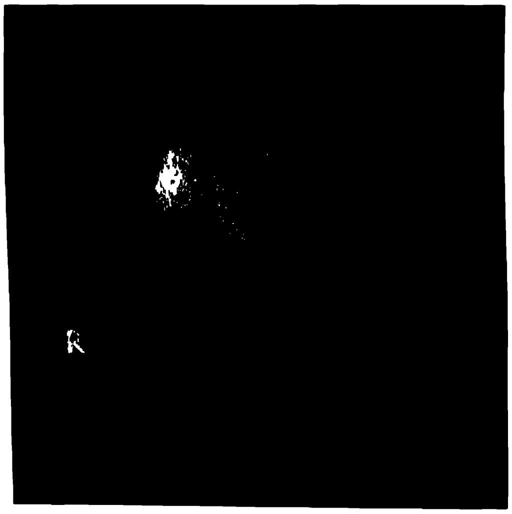

214

Lower Extremity: Knee Joint

LATERAL *(continued)*

SUBLUXATION OF KNEE JOINT

With the patient supine the limb is raised and supported, *in a relaxed state*, at the ankle joint, the film being placed vertically in contact with the lateral aspect of the knee.

CENTRE from the horizontal to the medial aspect of the knee joint.

NOTE—This condition of the knee joint may also be examined from the lateral aspect with the patient standing, the affected limb being slightly posterior to give separation of the limbs and in order that the displacement of the bones may be shown to full advantage.

OBLIQUE

The patient is placed in the prone position, with a sandbag under the ankles; then the affected limb is turned into the oblique position, first lateral and then medial.

CENTRE to the medial or lateral aspect as required.

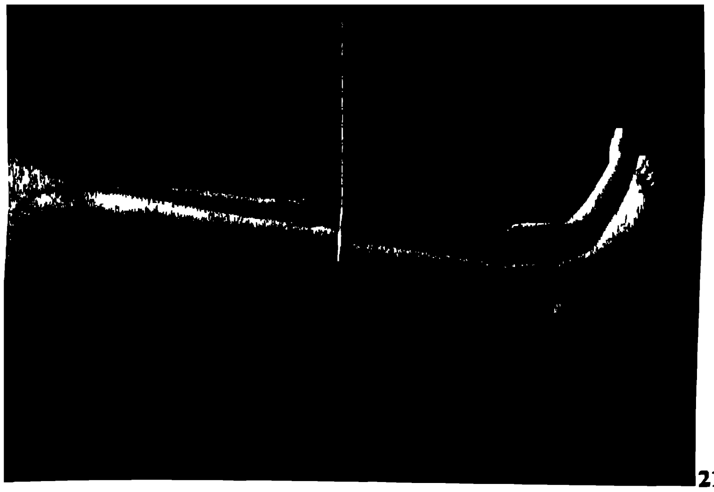
(211, 212, 213, 214)

NOTE—Half of the patella, separated from the femur, is shown from the postero-anterior aspect in each film.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	100	60	30″	Ilfex	—	—
60	10	6	36″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in.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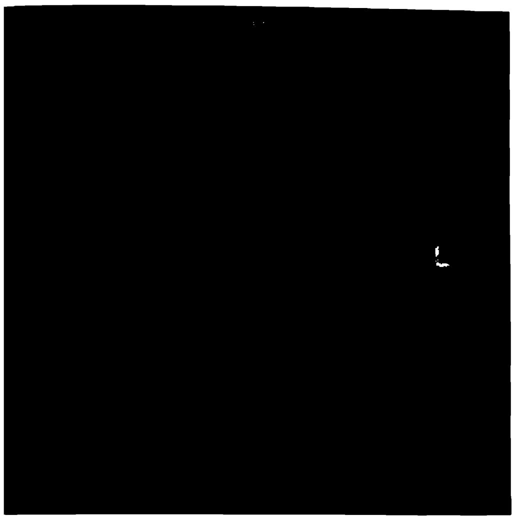
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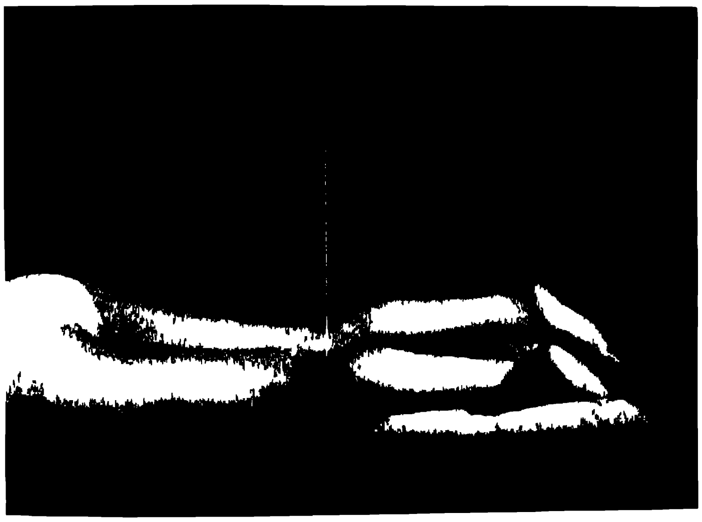
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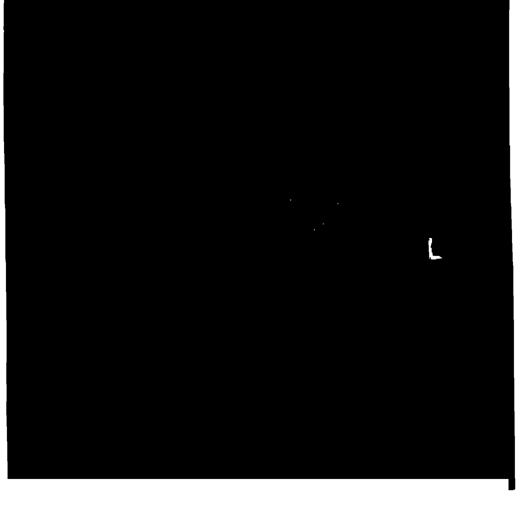

218

Lower Extremity: Knee Joint

PROXIMAL TIBIO-FIBULAR ARTICULATION ANTERO-POSTERIOR OBLIQUE

From the antero-posterior position the leg is rotated medially, so that the tibio-fibular articulation is projected clear of the tibial condyle, the foot being maintained in medial rotation.

CENTRE over the head of the fibula.

(215, 216)

NOTE—From that required for the general antero-posterior view of the knee the kilovoltage should be reduced by 5 kilovolts, since the small head of the fibula requires less penetration than the tibia.

LATERAL OBLIQUE

From the lateral position the leg is rotated medially, so that the head of the fibula is in contact with the film.

CENTRE over the head of the fibula.

(217, 218)

NOTE—The lateral oblique gives the most satisfactory view of the tibio-fibular joint.

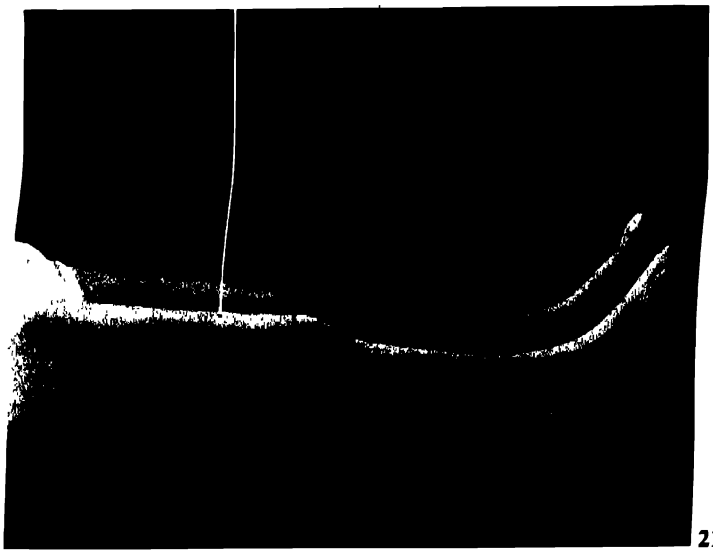
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	132	80	30″	Ilfex		
55	13	8	36″	Ilford	Tungstate	

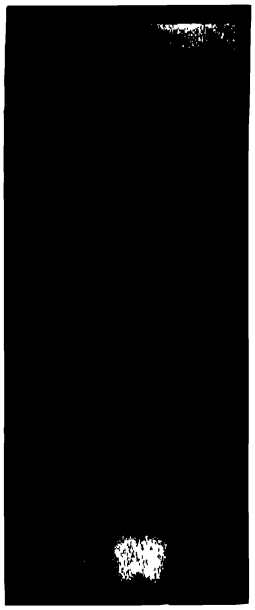
Cone to size of film, 8½ × 6½ in.

Lower Extremity

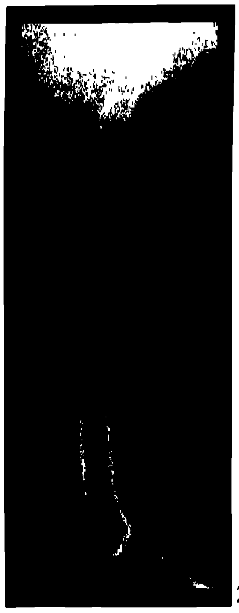
Femur—Lower Two-thirds



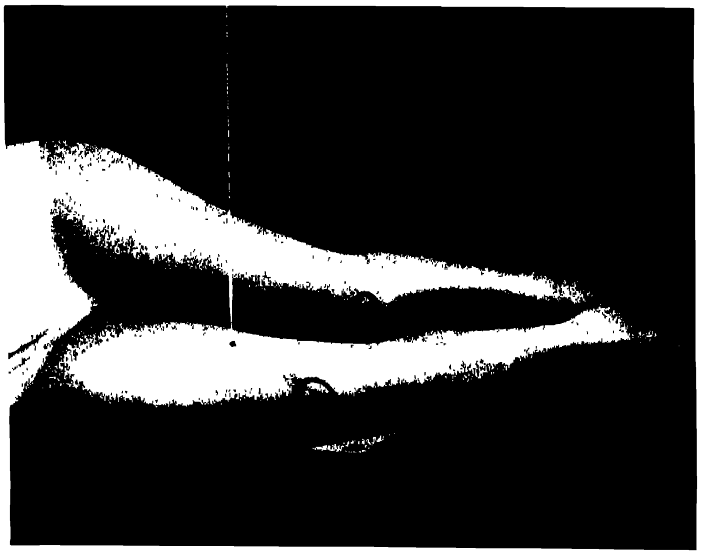
219



219a



219b



220

ANTERO-POSTERIOR

With the patient supine the leg is rotated slightly outward. The film should be placed well below the knee to ensure that the joint is included.

CENTRE to the middle of the film.

(219, 219a)

LATERAL

The patient is turned on to the affected side, with the knee flexed and the foot raised on a small sandbag.

The sound limb is supported at hip level, either in front of or behind the injured limb.

CENTRE to the middle of the film.

(220, 219b)

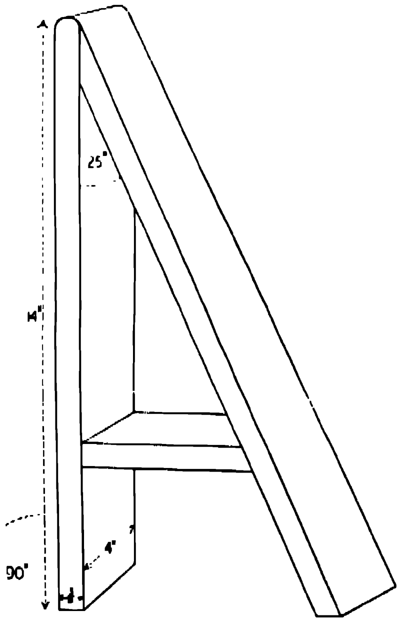
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	132	80	30″	Ilfex	—	—
65	13	8	36″	Ilford	Tungstate	—

Film, 15 × 6 in. or 17 × 7 in.

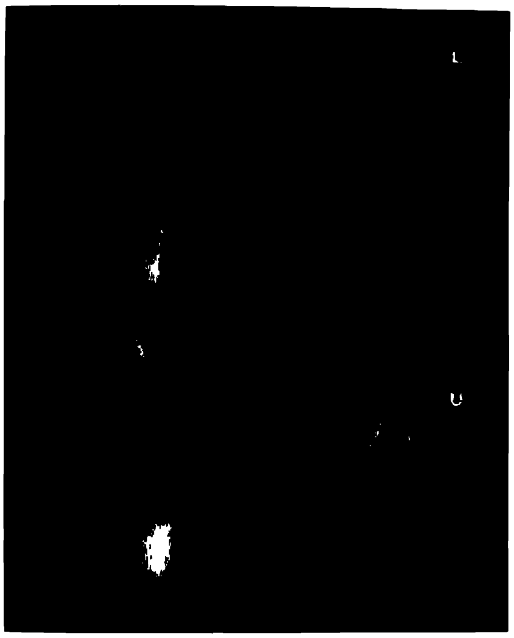
STRETCHER PATIENTS

When the injury is such that it is not desirable to turn the patient on to the side for the lateral view, the film is placed vertically against the outer aspect of the injured thigh. The sound limb is raised and supported on an angle block, and the X-ray beam is projected horizontally



221


221a


221b

222

STRETCHER PATIENTS (*continued*)

toward the medial aspect of the injured thigh (**221, 219b**). The fracture radiographs (**221b**) were taken under these conditions.

The diagram (**221**) shows the dimensions of a suitable angle support. Others may be made in various sizes to suit the requirements of the X-ray department. A wool bag between the supported limb and support is essential for the patient's comfort, and the support is kept in position by placing a sandbag on the shelf between the sides and also on the couch against the oblique foot. The feet of the support should not be joined at their extremities or there will be difficulty in placing it in position on the couch; nor should there be permanent weighting with lead, or the bone will be obscured on occasions when it is necessary to centre through the support.

AMPUTATIONS

The examination of a limb-stump may present a special problem, as it is difficult to immobilise the limb in position; the bone may be rarefied, this depending in degree on the lapse of time since the amputation; and it should be remembered that it is the condition of the extremity of the bone and the surrounding soft tissues which is being investigated.

Sandbags are used for the immobilisation of the limb and the adjacent joint, and the Potter-Bucky Compressor band, or a band with weighted ends (**196**), will prevent uncontrolled movement.

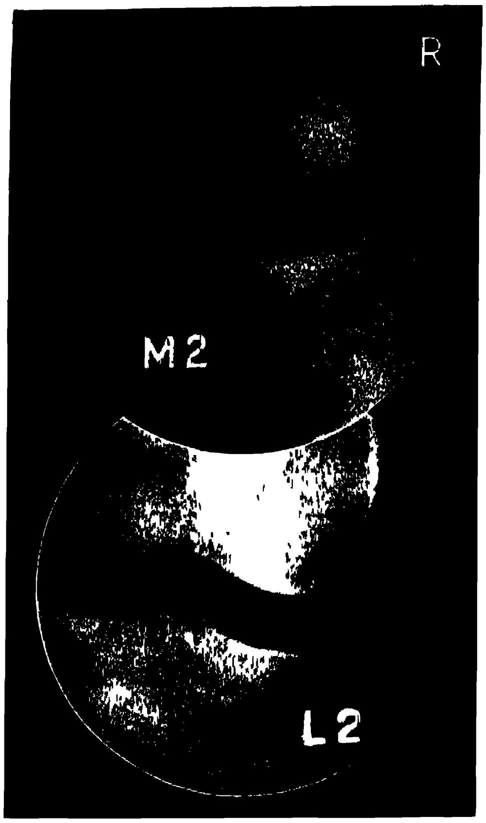
Standard antero-posterior and lateral views should be taken and also either stereoscopic views or special views to show the severed surface of the bone, using a tube tilt of approximately 30 degrees.

The exposure technique should be adjusted to obtain good bone and soft tissue detail, and for short exposure time.

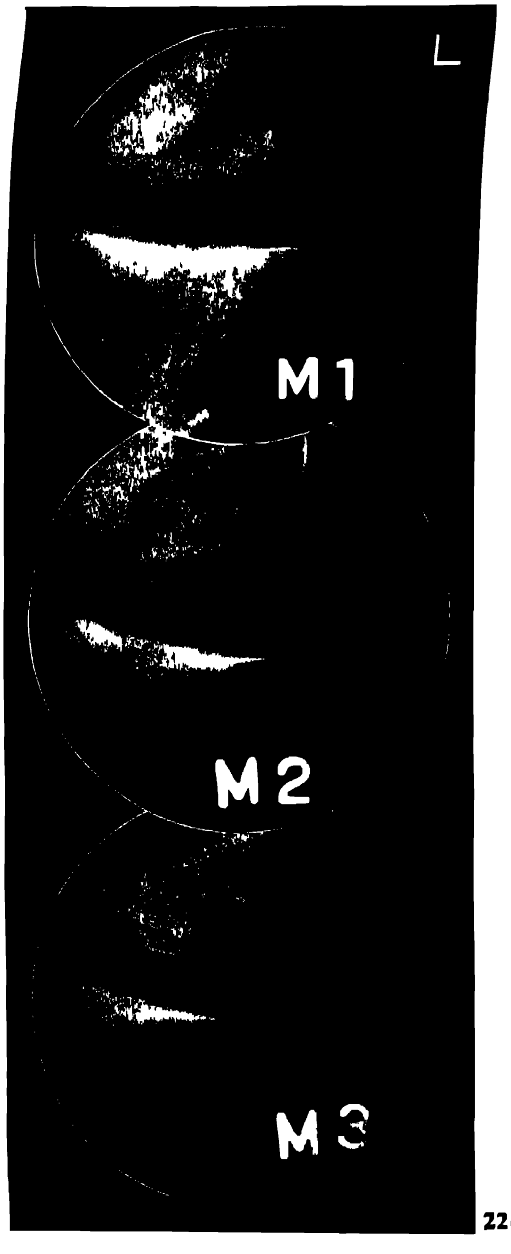
Pneumoarthrography

The two semilunar cartilages (menisci) of the knee joint are interposed between the femoral and tibial condyles. The medial meniscus is C-shaped, and the lateral is more nearly circular: both are thicker at the outer border than at the inner. The medial cartilage is more firmly fixed than the lateral and is therefore more readily injured.

X-ray examination of the knee joint to show derangement of the cartilages is of little value unless a contrast medium is previously injected into the joint space, the injection of oxygen for this purpose being known as pneumoarthrography. The amount of oxygen injected is



223



224

PNEUMOARTHROGRAPHY (*continued*)

of the order of 80 and 140 cubic centimetres. During the 24 hours preceding the injection aseptic preparation of the skin is applied. Before the X-ray examination the suprapatellar pouch is compressed by placing an elastic bandage above the knee joint, thus forcing the supra-patellar oxygen between the articular surfaces to enable the low density cartilages to be demonstrated. The X-ray examination may be made up to six hours following the injection.

Positioning is to show in turn the anterior, middle and posterior portions of each cartilage, using a localising cone of 3-inch aperture close to the skin surface. Fine grain intensifying screens are used and short exposure time is employed, with carefully selected exposure conditions to give satisfactory definition and suitable contrast. There is a tendency to prefer the type of radiograph resulting from over-exposure and under-development.

The supine position may be used with the curved cassette, but the prone position is preferred by some workers as it enables the more complete filling of the posterior parts of the joint spaces to be obtained. With the patient in this position, and with the knee slightly flexed, visual screening is first employed to enable the upper level of the tibial condyles to be marked on the skin surface for guidance in centring. Using lead letter indicators "M" or "L" for medial or lateral cartilage, and appropriate lead identification figures, three views are taken of each cartilage, (1) postero-anterior with rotation inward, (2) postero-anterior, and (3) postero-anterior with rotation outward, these six exposures being made on one 12-inch by 10-inch film. Two additional exposures complete the examination —lateral with the knee flexed, and an antero-posterior, also with the knee flexed, as for the intercondyloid notch (page 76), these being taken each on a single $6\frac{1}{2}$-inch by $4\frac{3}{4}$-inch film. The tube is centred over the cartilage, and for the six postero-anterior views the part of the joint under examination is opened up by forcible abduction or adduction of the tibia on the femur. This manipulation imposes considerable strain on both operator and patient, hence the necessity for a short-time exposure technique.

The two radiographs (**223**) show normal semilunar cartilages, M2, medial, and L2, lateral. Series (**224**) of the medial cartilage taken in the postero-anterior position—M1 with rotation inward, M2 without rotation, and M3 with rotation outward—show a tear through the body of the cartilage. These two series of radiographs were taken during the application of forced abduction and adduction to show the medial and lateral cartilages respectively.

SECTION 4

Hip Joint and Upper Third of Femur

HIP JOINT AND UPPER THIRD OF FEMUR

The hip joint is a ball and socket joint, the smooth, almost spherical head of the femur articulating with the acetabulum, which is formed by the three parts of the innominate bone on the lateral aspect of the pelvis. The upper extremity of the femur consists of head, elongated neck and the greater and lesser trochanters.

Films of the hip joint should include the upper extremity and upper third of the shaft of the femur, and should show the pelvis from the anterior superior iliac spine to the symphysis pubis. Until recently it was considered sufficient to take antero-posterior views of both hips for comparison, with stereoscopic views of the individual hip, but modern methods allow lateral views to be taken in practically every subject radiographed.

In placing the patient in position it is important to adjust the pelvis symmetrically from side to side; this can be checked by a spirit level resting upon the two anterior superior iliac spines. The protractor shown in the illustration serves many other purposes, the straight bar only, with the spirit level on one side, serving to adjust the pelvis to the correct level **(225)**.

Where wasting of the buttock or the presence of an abscess on the affected side causes the pelvis to tilt from the true antero-posterior position, the condition may be compensated for by placing a soft wool pad under the buttock and thigh of the side nearer the film, so that the pelvis may become symmetrical in relation to film and tube.

It should be remembered that rotation of the whole limb on its axis is from the hip joint, so that the position of the foot in normal subjects is an indication of the relationship between head and neck of femur and acetabulum. In *abnormal* conditions of the hip joint, therefore, the position of the foot is an important clue to the injury sustained.

It is important to recognise the varying appearances of the hip joint as the head of the *femur* is rotated medially or laterally. The medial or lateral rotation of the *foot* is a guide to the position of the head of the femur.

Medial rotation of the foot indicates that the femur is rotated medially, and in the radiograph the femoral neck appears to be *elongated* and *less oblique* in direction as compared with the "foot straight" view. The greater trochanter is rotated forward, and the lesser trochanter backward until it is obscured by the shaft of the femur **(226, 227)**.

Lateral rotation of the foot indicates that the head of the femur is rotated laterally in the acetabulum. The femoral neck appears to be *foreshortened* and *more oblique* in direction. The greater trochanter is seen obliquely, and the lesser trochanter becomes conspicuous **(228, 229)**.

The generally recognised position is with the feet straight **(230)**, resulting in radiograph **(231)**.

In short anode-film distance technique—not exceeding 30 inches—the appearance of the femur also varies with the centring point, *i.e.*, whether centred over the femoral head for one hip, or in the mid-line for both hips **(234, 237)**.

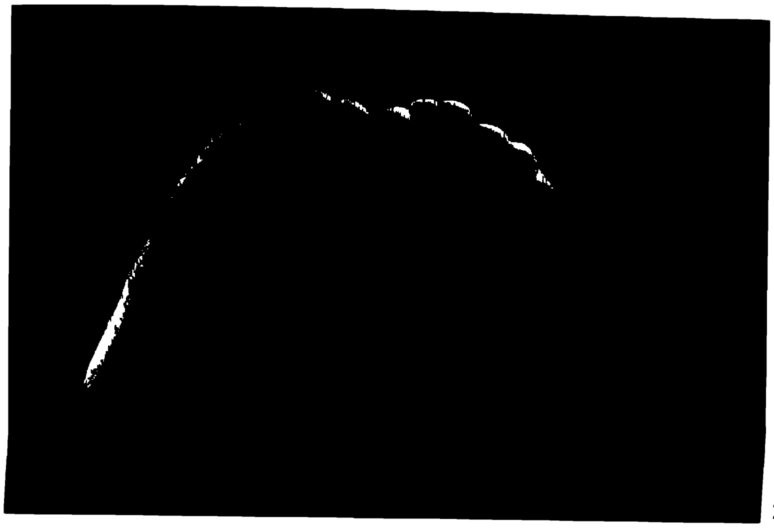
The hip joint is always radiographed with the aid of intensifying screens, and usually with the addition of either the Potter-Bucky diaphragm or the stationary grid.

The flat-topped diaphragm is most suitable for single hip joint technique. When the curved Potter-Bucky diaphragm is used it is necessary to place sandbags carefully under the back and thigh, above and below the hip joint, to prevent tilting of the pelvis.

The exposure factors quoted in this section refer to an adult male subject weighing 150 pounds and having a height of 5 feet 10 inches.

For smaller subjects the penetration should be reduced by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent.


225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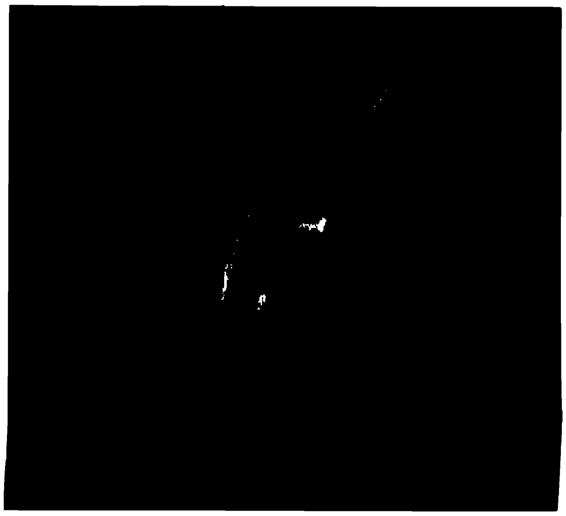
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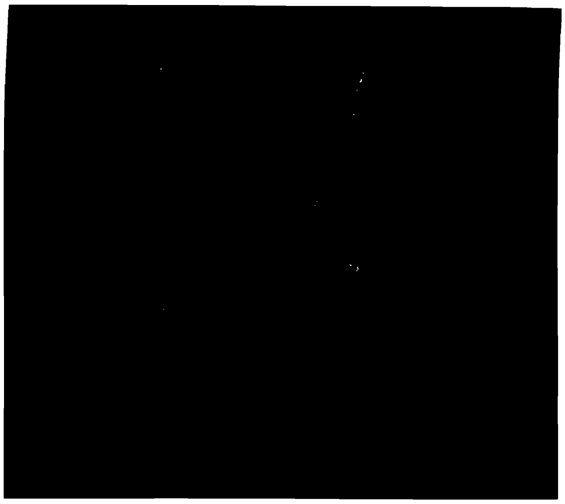
228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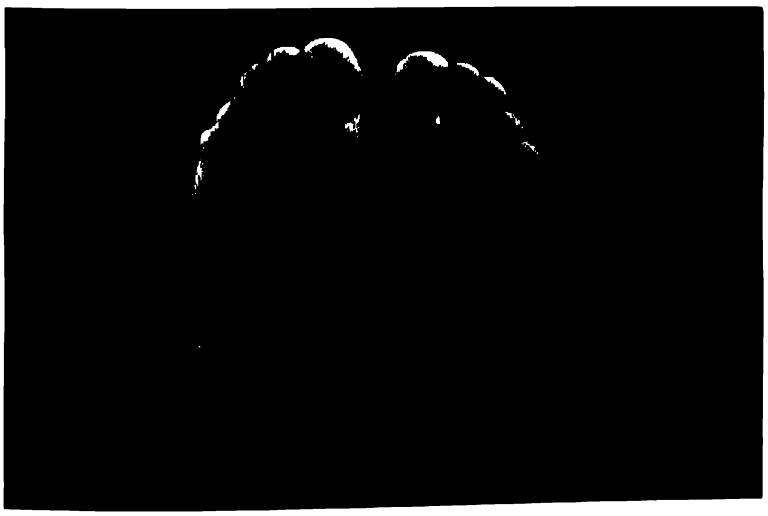
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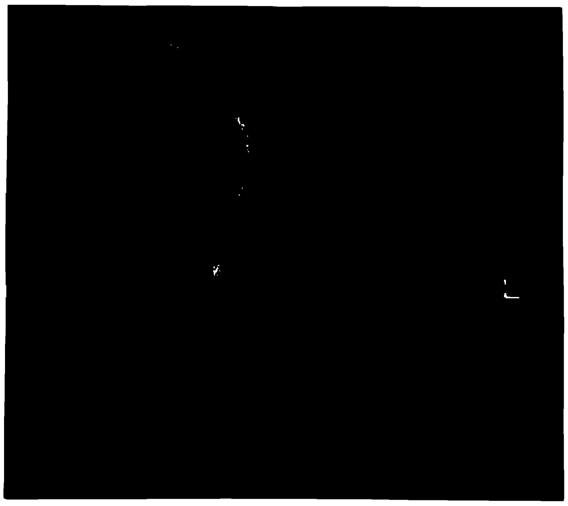
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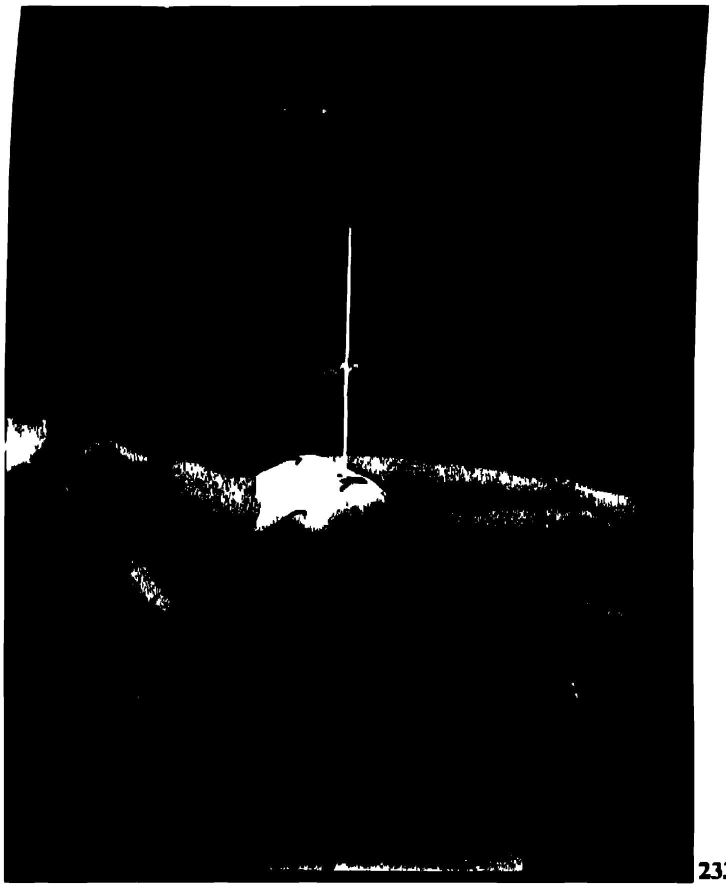
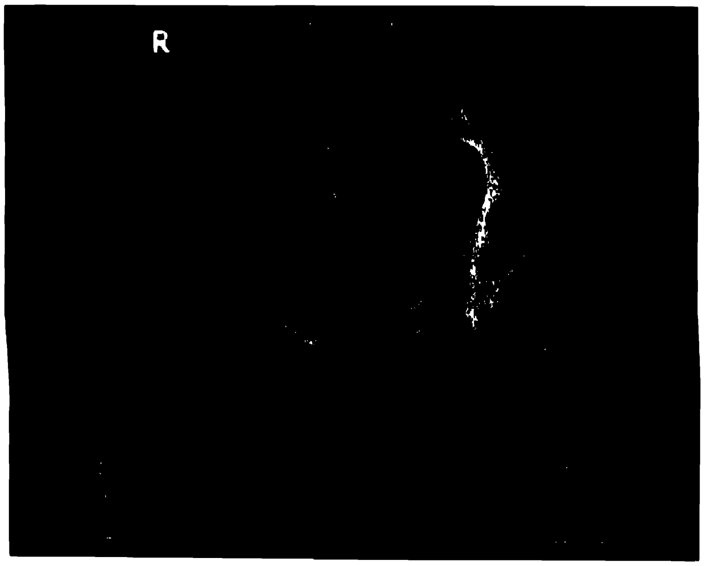
232



233



234

Hip Joint and Upper Third of Femur

Both Hips

ANTERO-POSTERIOR

It is preferable to include both hips on the same film, for purposes of comparison, especially in children, when it is essential that both hips be taken at a single exposure in order to show any fine variations in contrast and density which may indicate early disease.

The patient is supine and the pelvis is adjusted so that the transverse plane is parallel to the film. This position is checked by placing the rod carrying the spirit level across the anterior superior iliac spines; or with a thumb on each iliac spine and the fingers in contact with the couch, the pelvis is rotated into the correct position. In addition, it is important for the pelvis to be central to the couch and film.

Both feet are sandbagged in similar positions, preferably with the longitudinal axis of the soles of the feet at right angles to the couch.

(230, 232)

A small sandbag is placed between the heels to give slight but equal abduction to the limbs, and a sandbag under the knees adds greatly to the patient's comfort.

(232)

CENTRE for both hips in the mid-line, 2 inches below the level of the anterior superior iliac spine, or one inch above the upper border of the symphysis pubis.

(233, 234)

NOTE—The depression in the lateral aspect of the thigh indicates the correct level of the hip joint.

The film should be large enough to include both trochanters, and should be chosen according to the width of the patient.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	35	21	30″	Ilford	Tungstate	—
*65	94	57	30″	Ilford	Tungstate	Stationary
65	132	80	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in., 15 × 12 in. or 17 × 14 in.

* Ward mobile unit.

235

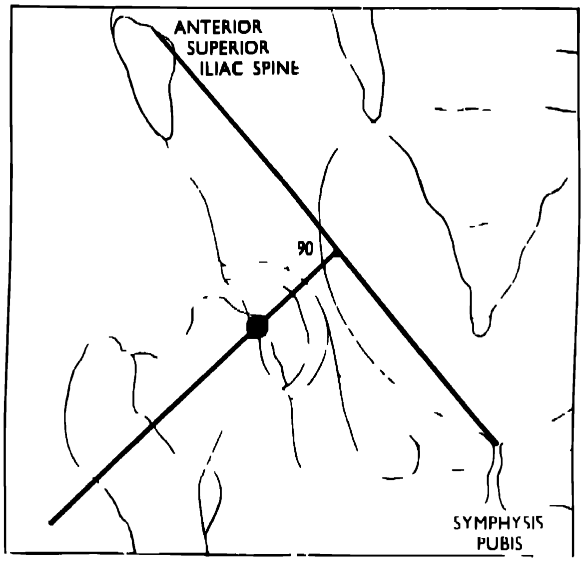
Hip Joint and Upper Third of Femur

Single Hip

ANTERO-POSTERIOR

Individual hip joints may be localised by bisecting at right angles a line joining the anterior superior iliac spine and the upper border of the symphysis pubis.

(235, 236)



236

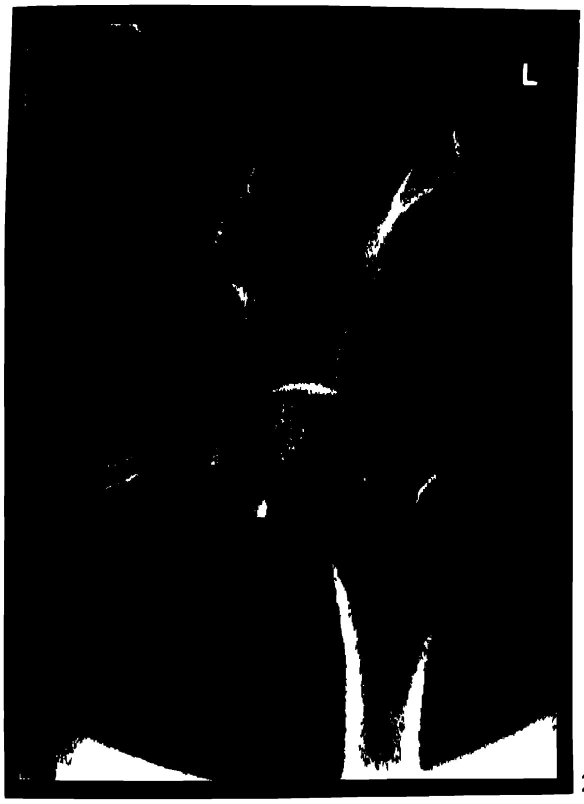
CENTRE on the bisecting line at a point one inch below the point of inter-section (235, 236, 237).

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	40	25	30″	Ilford	-	
*65	112	68	30″	Ilford	-	Station-ary
65	264	160	48″	Ilford	-	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

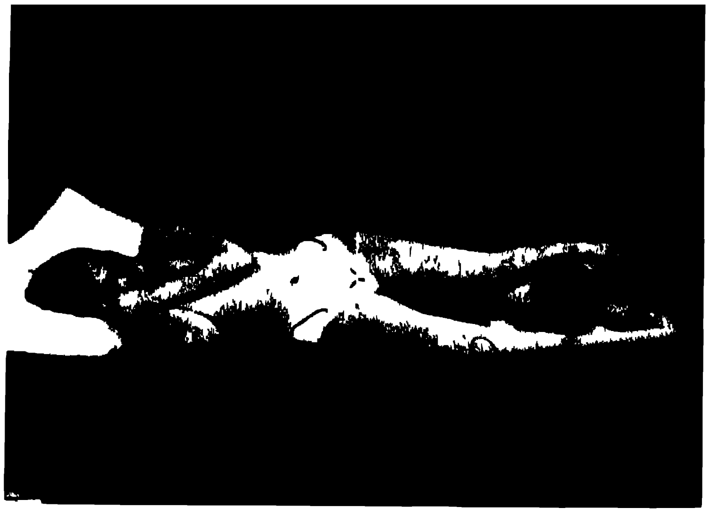
* Ward mobile unit



237

Injury to the neck of the femur usually gives rise to lateral rotation of the limb and foot, as shown in (238), and it is thus impossible to place the foot in the generally recognised correct position with the foot pointing upward. In this type of injury the radiographer may be required to take the opposite hip for comparison, either in the normal position (238) or with the limb in the same position as that on the injured side (228).

238



239

Hip Joint and Upper Third of Femur

LATERAL

When able to be moved without discomfort, the patient is turned on to the affected side, with flexion at hip and knee joints, the pelvis is tilted 45 degrees backward and the good limb raised and supported in a comfortable position.

NOTE—It is necessary to place the cassette obliquely on the Potter-Bucky tray, with the upper corner well above actual hip level in order to accommodate the oblique position of the limb.

CENTRE to the upper third of the femur.

(239, 241)

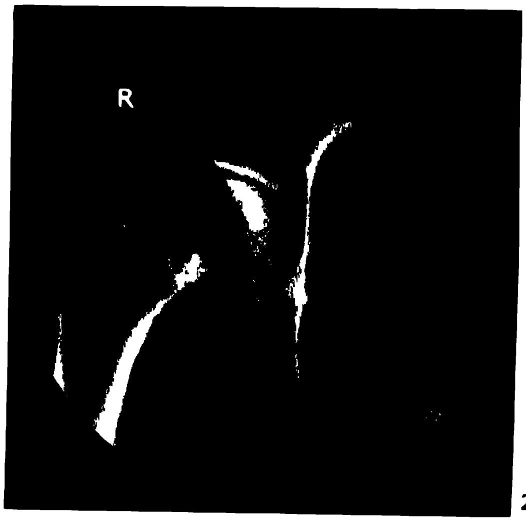
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	40	25	30″	Ilford	Tungstate	—
*65	112	68	30″	Ilford	Tungstate	Stationary
65	264	160	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

* Ward mobile unit.

In this view all structures entering into the hip joint and the upper third of the femur are visible.

Radiographs **(240, 241)** showing an exostosis, and **(242, 242a)** showing a fracture, indicate the importance of taking the lateral view.



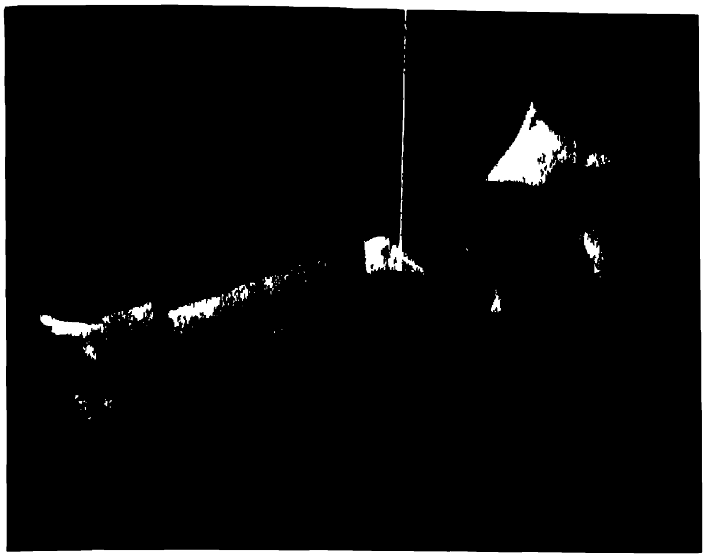
240

241

242

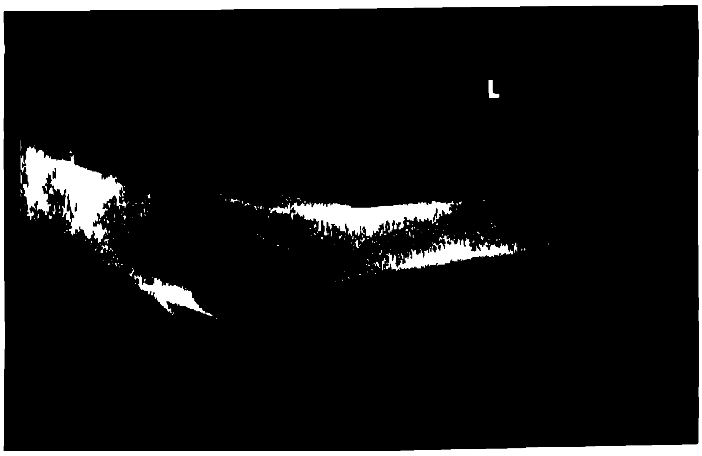
242a

Hip Joint and Upper Third of Femur



243

244



245

STRETCHER AND WARD PATIENTS

In many instances it is not advisable to move the patient from the stretcher trolley, while in others the examination is made in the ward. In either case the patient remains supine during the complete examination, and both views are taken with the ward mobile unit. The stationary grid is an asset in these cases.

ANTERO-POSTERIOR

Patients direct from the casualty department are frequently fully clad. In dealing with male patients it is necessary to slip the trousers below the hip level, or the opacities in the pockets may obscure an important part of the bone; with women patients corsets and suspender fittings may be equally troublesome. Suitable coverings such as dressing towels and blankets should be available. In raising the pelvis to adjust the clothing and to place the film in position great care should be taken to *support the injured limb.*

For purposes of treatment ward patients are usually immobilised, and any movement required in placing the film should be made at the discretion of the sister in charge.

(243)

LATERAL

The film is placed against the lateral aspect of the thigh well above the hip joint, the sound limb being raised and supported. The tube is centred from the horizontal position to the medial aspect of the upper third of the shaft of the femur, and is directed obliquely toward the joint.

Satisfactory views are obtained of the upper third of the shaft and of the hip joint.

(244, 245)

EXPOSURE FACTORS

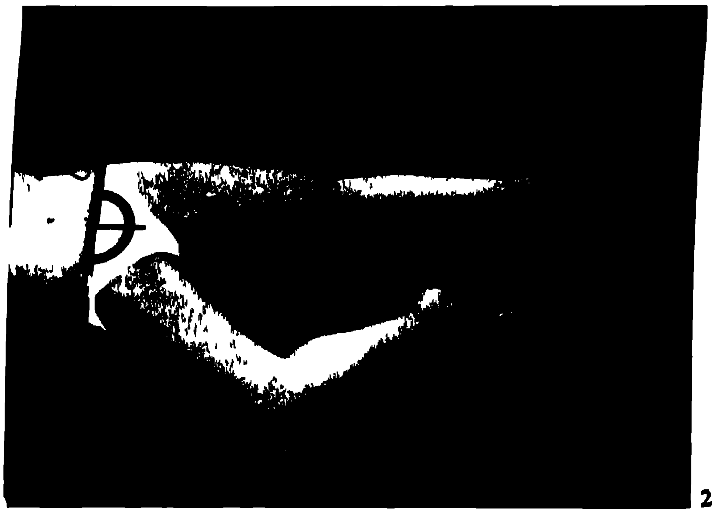
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*75	75	45	30"	Ilford	Tungstate	—
*75	205	124	30"	Ilford	Tungstate	Stationary

Cone to size of film, 10 × 8 in., 12 × 10 in. or 12 × 6 in.

* Ward mobile unit.

NOTE—In all cases the lateral view of the hip joint becomes a part of the routine examination as in other joints.

246



247

248

249

Hip Joint and Upper Third of Femur

CONDITIONS REQUIRING SPECIAL TREATMENT

In radiographing a diseased hip, with the affected side or both sides fixed in position, it is usual to take both hips for comparison, with both limbs in the same position (**246**). Others are taken as in (**247**), with the sound hip in the normal position. This type of case can still be taken with the pelvis symmetrical. Differences in bone densities are also important, hence the necessity for taking both hips on the same film.

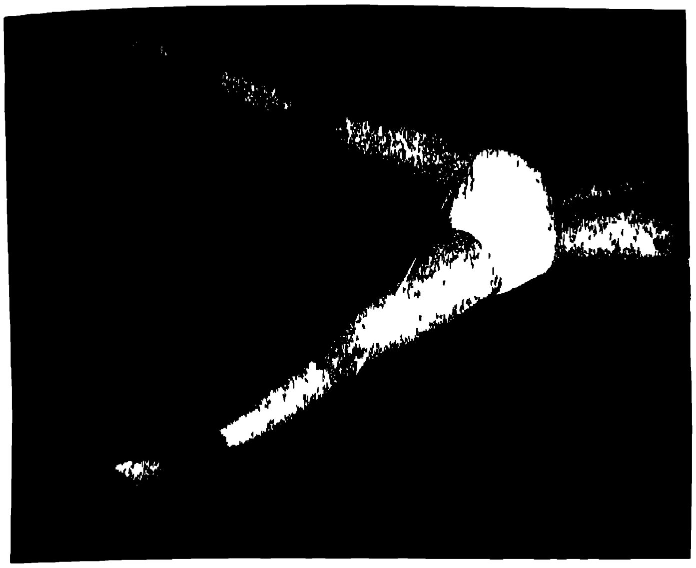
Radiograph (**248**) shows some tilting of the pelvis which, although almost negligible, is sufficient to produce a variation in density between the two sides which might lead to a misleading interpretation, especially in cases of early bone changes in children.

Follow-up films taken over a long period should be of the same quality, and each should be taken in the identical position as regards limb and pelvis. There is no excuse for a distorted view of the pelvis, even under the conditions suggested in (**249**), but where actual malformation is present, stereoscopic views are imperative. To include a dislocated femur (**250**), due to trauma or disease, adjustment of the film to a higher level may be necessary.

The kilovoltage may be varied to suit the conditions radiographed as compared with the normal subject. For example, loss of bone calcium following a long period of rest may suggest a lower kilovoltage as compared with that used for the original exposures, otherwise the films may be valueless owing to over-penetration.

Hips treated on extension frames or in plaster of Paris splints present special problems, especially in taking radiographs from the lateral aspect. In these cases, when both hips are in plaster in abduction, it is rarely possible to obtain satisfactory lateral views by the ordinary methods.

250



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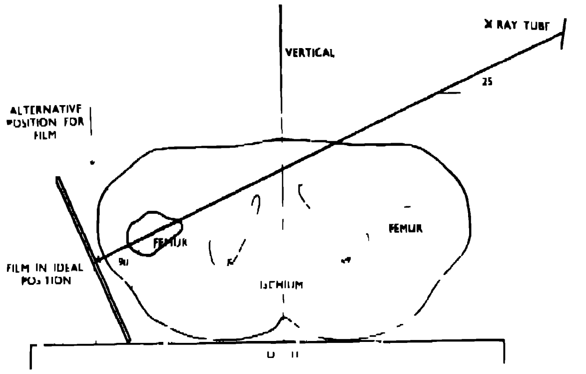
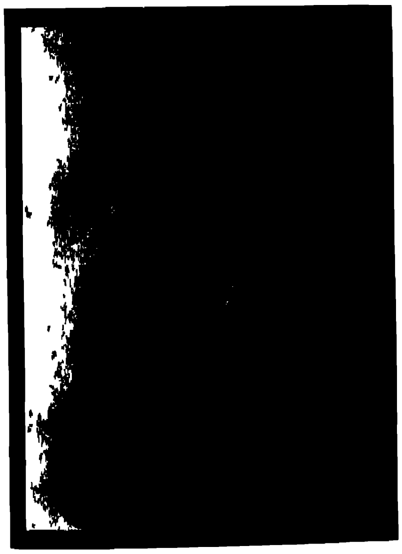
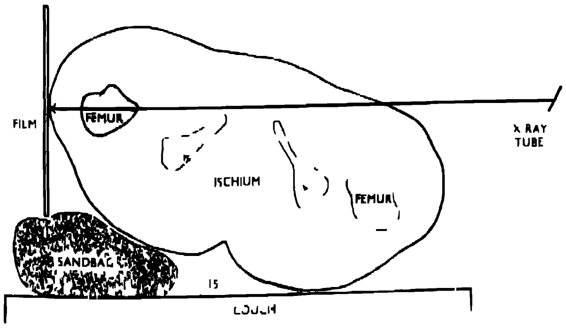


252



253



254

Hip Joint and Upper Third of Femur

LATERAL (1)

When the patient cannot be moved from the supine position the film is placed against the outer side of the thigh.

CENTRE toward the hip joint from the medial aspect of the thigh, with the tube angled 25 degrees above the horizontal (251, 253).

The cross-sectional diagram (252) shows the X-ray beam directed above the opposite hip joint, with the film tilted slightly under the hip, to be at right angles to the X-ray beam, and also indicates the alternative vertical position of the film which is necessary in the presence of awkward appliances.

LATERAL (2)

When the pelvis can be tilted so that the hip being examined is above the level of the other hip, it should be supported in position by sandbags, with the film placed in the vertical position against the outer aspect of the thigh.

CENTRE from the horizontal, above the sound side, toward the hip and film.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*72	160	97	30″	Ilford	Tungstate	—
*82	215	130	30″	Ilford	Tungstate	Stationary

Cone to size of film, 10 × 8 in. or 12 × 10 in.

* Ward mobile unit.

The cross-sectional diagram (254) shows the position of the two hips when the pelvis is tilted, the film in position, and the direction of the X-ray beam.

255

256

Hip Joint and Upper Third of Femur

Neck of Femur

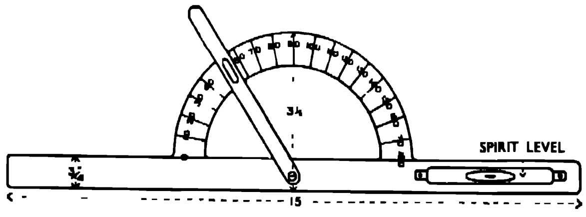
LATERAL

This view is important in connection with the Smith-Petersen operation, where, following reduction of the fragments in fractures of the femoral neck, the surgeon depends upon guidance from the radiographs in inserting a triradiate stainless steel nail through the greater trochanter and long axis of the neck into the head of the femur (258, 259).

True antero-posterior and lateral views are assured by maintaining the position of the limb and by using vertical and horizontal spirit levels clipped on to the cassettes (260) for guidance in placing the film in position.

To determine the position of the neck of the femur from the antero-posterior aspect, a protractor is applied to the antero-posterior radiograph with its base between the upper border of the symphysis pubis and the anterior superior iliac spine (255). The protractor arm is adjusted to the long axis of the femoral neck, and the protractor transferred from the film to the patient, when, using the same landmarks, the position of the neck may be marked on the skin surface (256). The vertical film is then placed parallel to the line on the skin and the central ray from the tube is projected at right angles to neck and film, using a long rod to indicate the direction of the beam. With a little practice the use of the protractor and the marking of the direction of the neck on the skin is unnecessary unless marked deviation of the fracture fragments is anticipated. In the majority of cases the neck is at an angle of 90 degrees to 100 degrees to the line joining the anterior superior iliac spine and symphysis.

The *film-subject* distance may be six inches or more, but this is compensated for by increasing the *anode-film* distance. A fine-focus tube, *which must be shock-free*, will give satisfactory results at 30 inches or less. An adjustable film support is necessary when the projection is made from the medial aspect of the thigh.



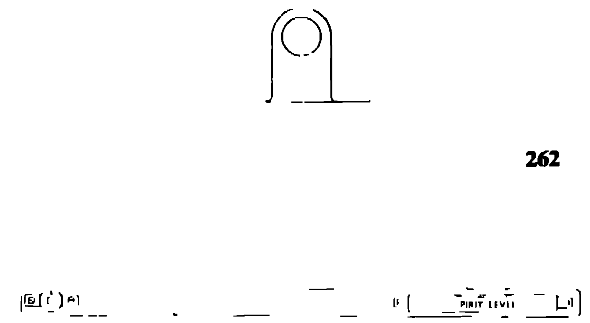
257

Diagram (257) gives the dimensions of a suitable protractor. The original model was of cardboard, with a drawing pin to attach the movable arm to the base.

Hip Joint and Upper Third of Femur

NECK OF FEMUR
LATERAL *(continued)*

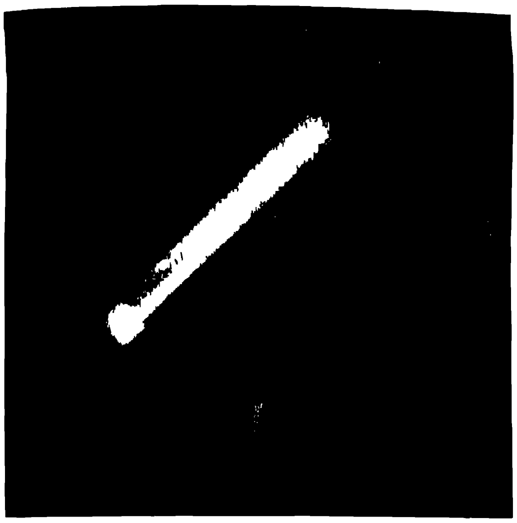
To determine the angle of rotation of the long axis of the neck of the femur a metal bar is clipped on to the cassette and adjusted to the horizontal position by means of attached spirit levels (260). The horizontal metal bar shows clearly in the radiograph, and the angle of rotation of the neck of the femur, medially or laterally, is thus determined (261).



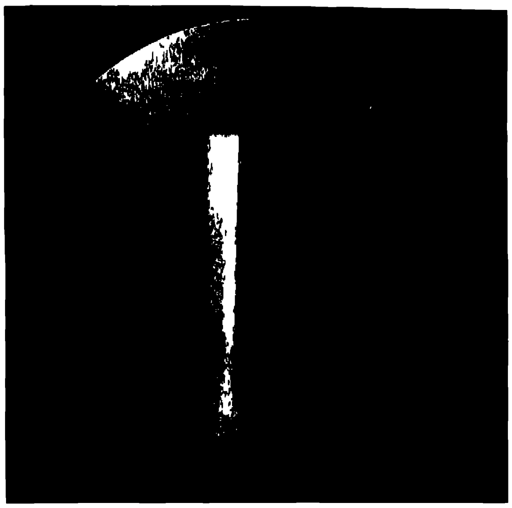
262

Diagram (262) gives the dimensions of a suitable clip. The long bar forming the base is lined with thin lead to give greater opacity in the radiographs.

The original model was made from the top of a broken developing hanger and a paper clip.



258



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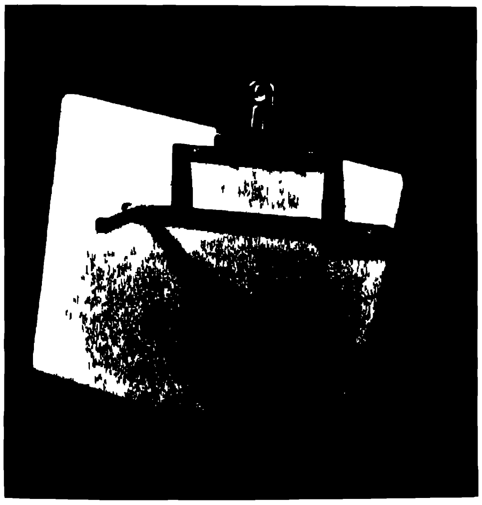

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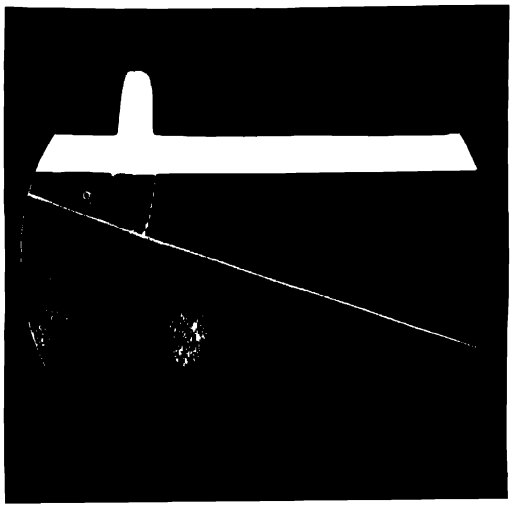

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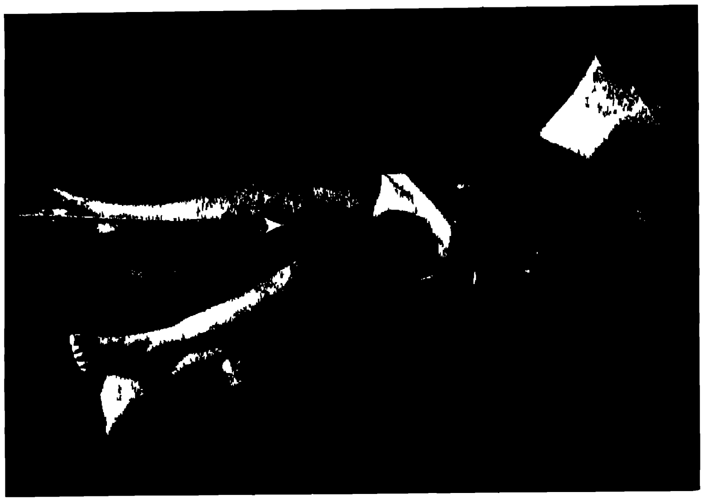
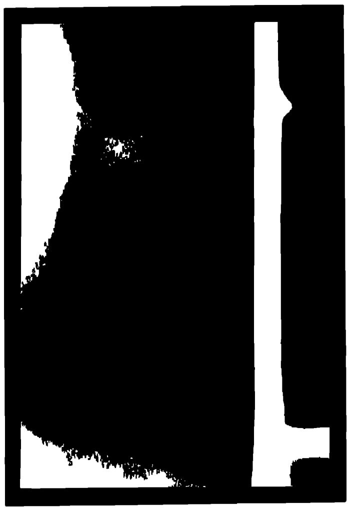

263


264


265


266

Hip Joint and Upper Third of Femur

NECK OF FEMUR
LATERAL *(continued)*

In positioning the patient considerable abduction of the limb is necessary, but over-abduction increases the difficulties in obtaining the correct relationship between tube, subject and film.

The examination is carried out with the ward mobile unit. If the unit is not shock-free great care must be taken in adjusting the tube, and the greater anode-film distance is essential. The stationary grid is an asset, but tends to prolong the exposure unduly unless the mobile unit is capable of a high output. The developing process should be speeded up to meet the requirements of the operating theatre.

There are several ways of carrying out the examination, as follows:—

1. In the operating theatre, following the reduction of the fracture, the patient is adjusted on the orthopædic table, or Shropshire horse, with both limbs fixed in abduction and the foot inverted. A slot in the table allows the antero-posterior film to be placed in position without moving the patient. The pelvic rest and perineal bar are made of lignum vitæ in place of metal so that the femur is not obscured in either direction.

For the lateral view the film is pressed well into the soft tissues above the iliac crest and parallel to the femoral neck: the special support holds the cassette in position. When working at the greater anode-film distance the tube is centred from the inner side of the foot of the sound leg, and the central ray is directed at right angles to the neck of the femur and the film. A rod, three feet in length, with a spirit level attached, is of great assistance to the less experienced worker in determining the correct level and direction of the X-ray beam. Strict asepsis is observed throughout **(263, 264)**.

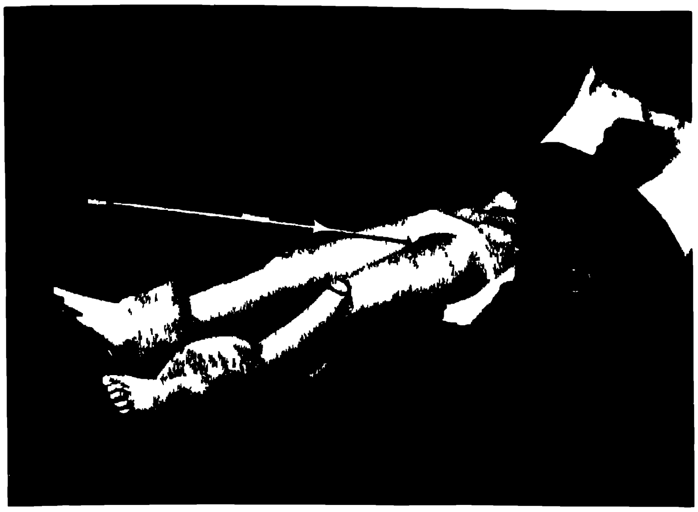
EXPOSURE FACTORS

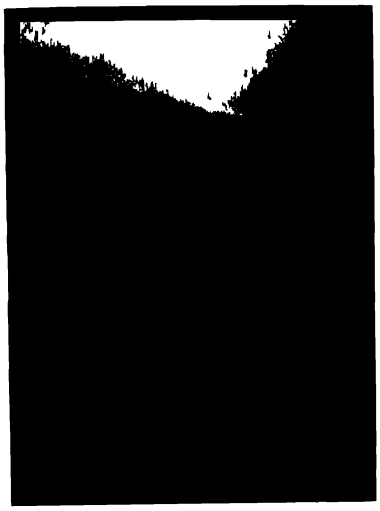
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*82	300	180	48″	Ilford	Tungstate	—
*82	375	228	54″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in. or 12 × 10 in.

* Ward mobile unit.

2. The same technique may be applied with the sound limb flexed and raised on a wooden block. The tube is centred from below the good limb and angling is simplified, but this method is not suitable in the operating theatre. **(265, 266)**


267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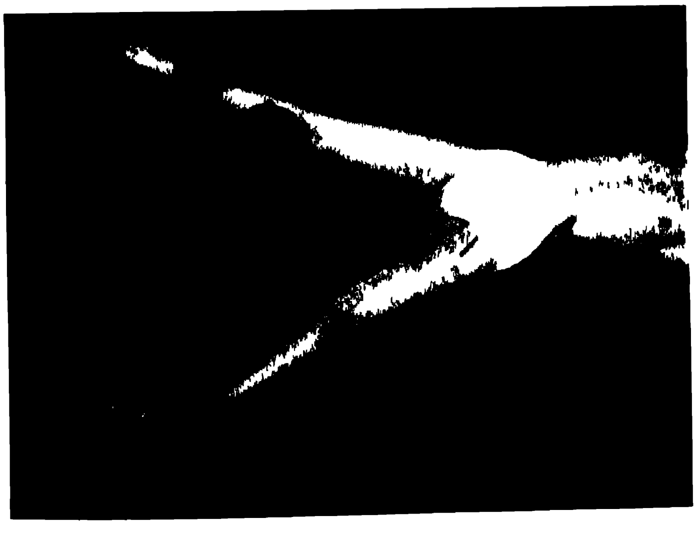
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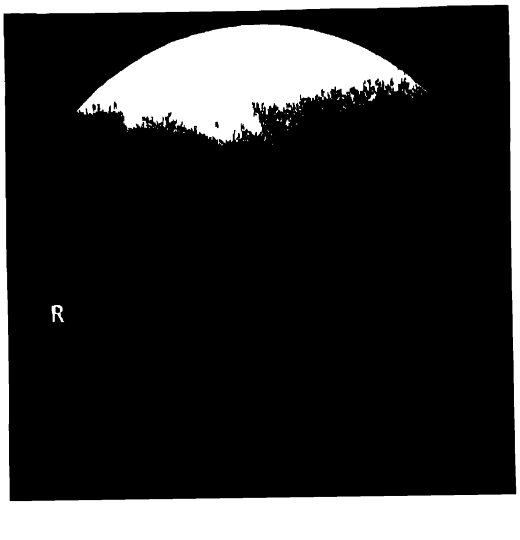


269a

Hip Joint and Upper Third of Femur

NECK OF FEMUR
LATERAL *(continued)*

3. The most satisfactory radiographs are obtained when the patient has recovered from the operation and is able to rotate the limb. The patient is supine, with the pelvis tilted to an angle of approximately 30 degrees and the injured limb raised and supported above the table level. Although the pelvis is tilted the limb is maintained in the true antero-posterior position.

The film is placed above the anterior superior iliac spine, parallel to the femoral neck, and the tube centred in the horizontal plane above the level of the sound limb, at an angle of 90 degrees to film and neck of the injured femur. In this position the femoral head and acetabulum are very clearly demonstrated. This position is also suitable when the patient is in plaster following the operation.

(267, 268)

EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*82	345	210	48″	Ilford	Tungstate	–
*82	—	352	36″	Ilford	Tungstate	Stationary

Cone to size of film, 10 × 8 in or 12 × 10 in.
* Ward mobile unit.

4. For short-distance technique with a small shock-free unit it should be possible to support the unit in position between the legs and at a 30 inch anode-film distance.

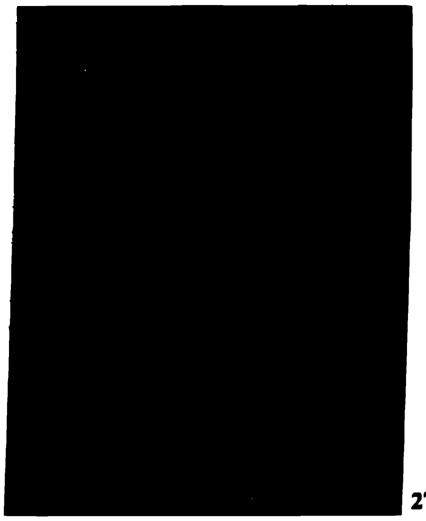
The central ray should be projected approximately at right angles to the neck of the femur and film. This position gives satisfactory results and may be used for most purposes.

(269, 269a)

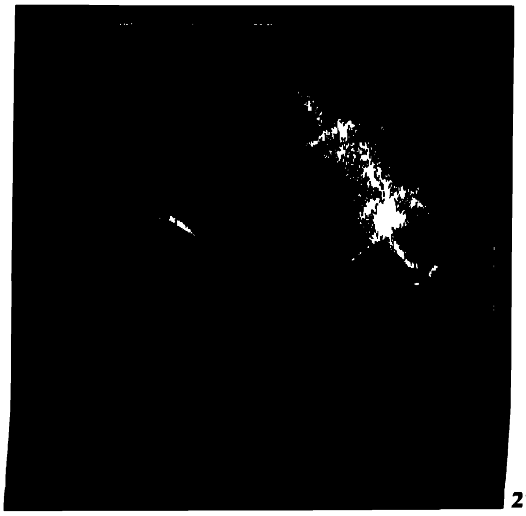
EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	230	140	24″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in
* Portable unit.



270



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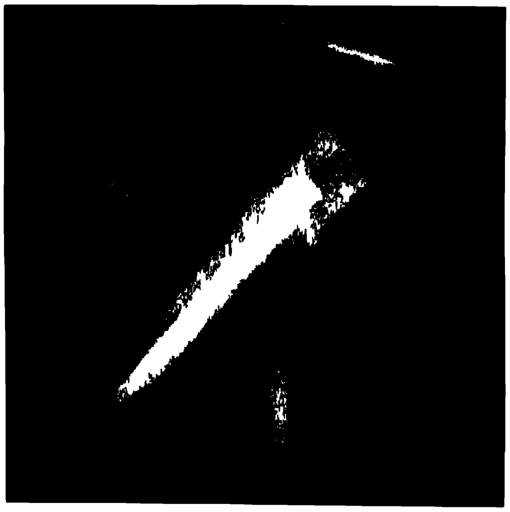


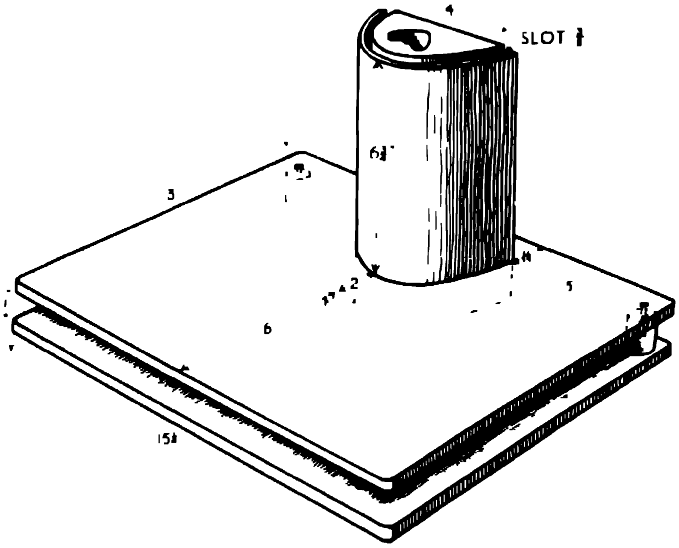
273

Hip Joint and Upper Third of Femur

NECK OF FEMUR
LATERAL (*continued*)

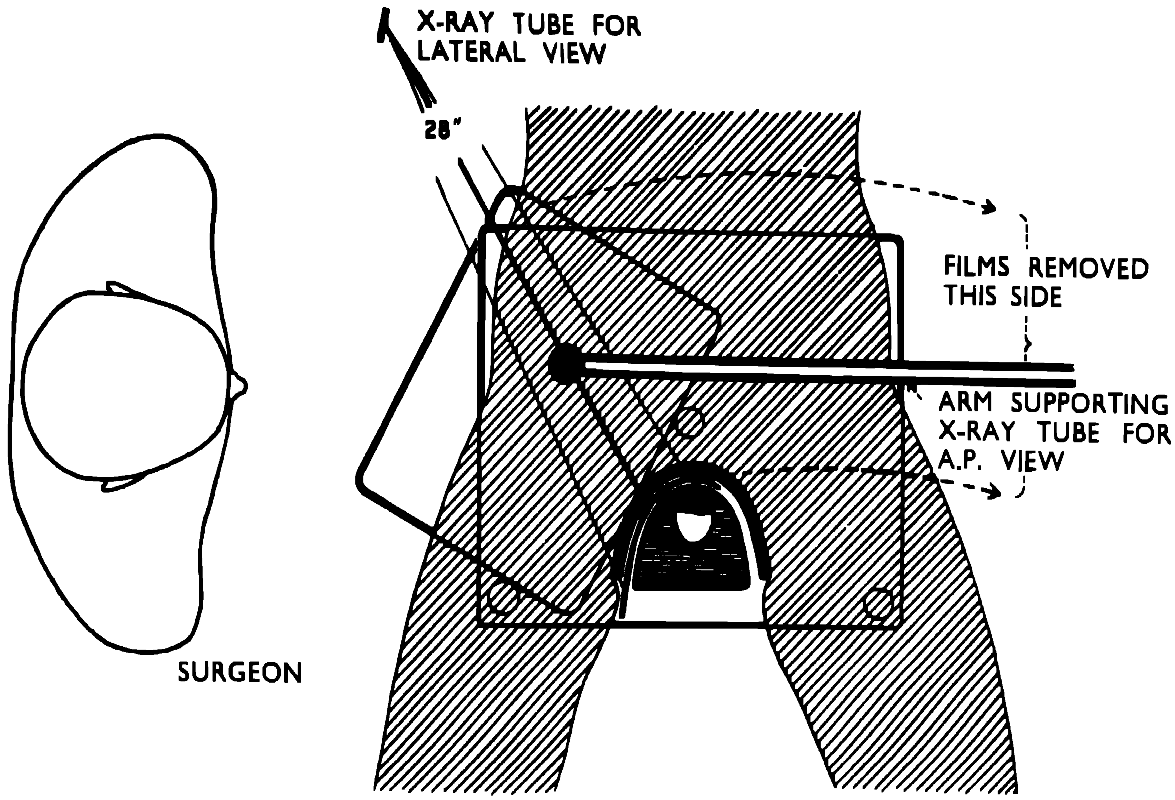
5. Another method of applying this technique, particularly in the operating theatre, is by using a specially designed combined horizontal cassette holder and vertical film pack holder for taking the antero-posterior and lateral views, respectively, this piece of apparatus replacing the normal buttock rest and perineal bar.

As shown in diagram (274), this cassette holder, the upper surface of which also forms the buttock rest, is constructed of two five-ply wood surfaces which are separated by three ¾-inch distance pieces so placed as to

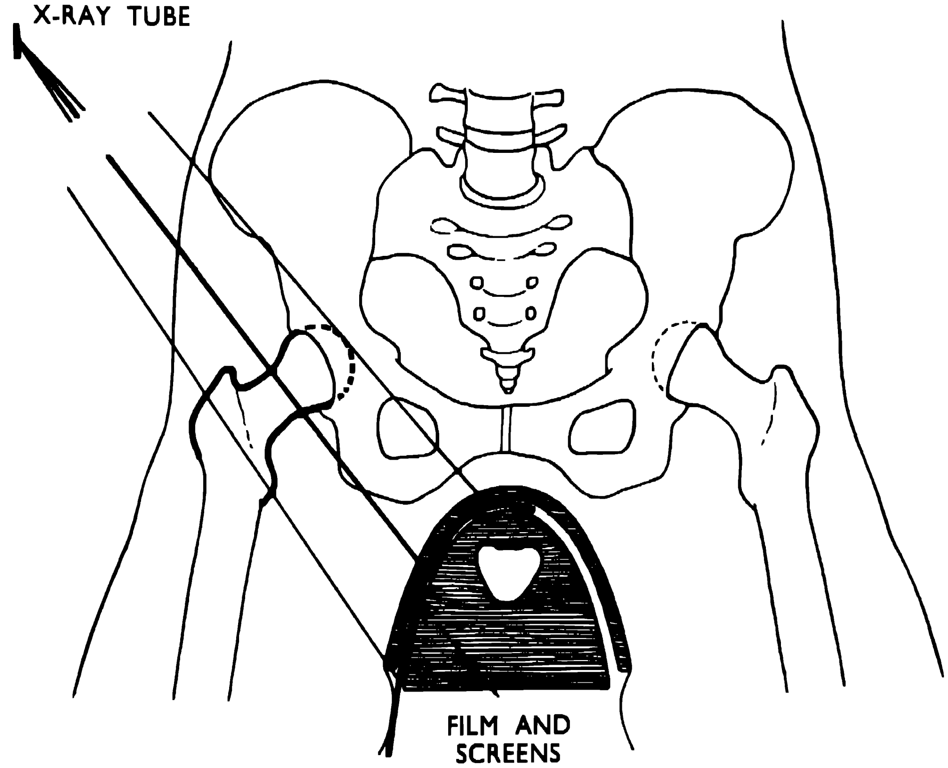


(274)

establish the position of the film for the antero-posterior view. The vertical film support, roughly semi-cylindrical in shape, consists of a block of wood fixed at one side of the surface of the buttock rest, and having a hole passing through its centre and continuing through both surfaces of the cassette holder, thus enabling the apparatus to be fitted over the normal perineal bar and locked in position on the theatre table. The curved surface is lead covered to absorb X-ray scatter, which would otherwise reduce definition, and is surrounded at a distance of ⅛-inch by a similarly curved piece of three-ply wood, a slot thus being formed to accommodate the special film pack used. As will be seen in diagram (276), this vertical film support forms an adequate "curved cassette" which, by virtue of its position and of the compression given by the extension of the limbs, is ideally placed for the lateral view, and this position is maintained throughout the operation. The film and the specially prepared thin flexible screens, in an envelope, are placed in the narrow slot, which is designed to give the necessary screen-film contact. The tube is

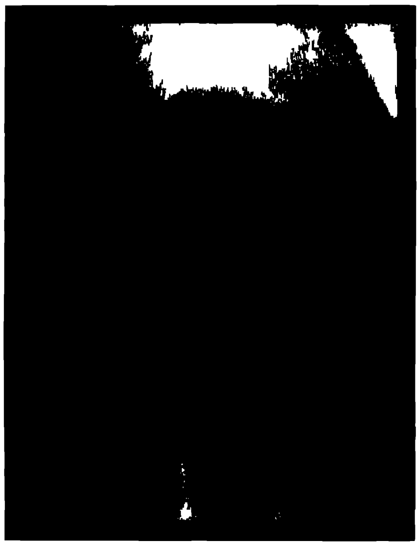

X-RAY TUBE FOR
LATERAL VIEW
28"
FILMS REMOVED
THIS SIDE
ARM SUPPORTING
X-RAY TUBE FOR
A.P. VIEW
SURGEON

275


X-RAY TUBE
FILM AND
SCREENS

276

277



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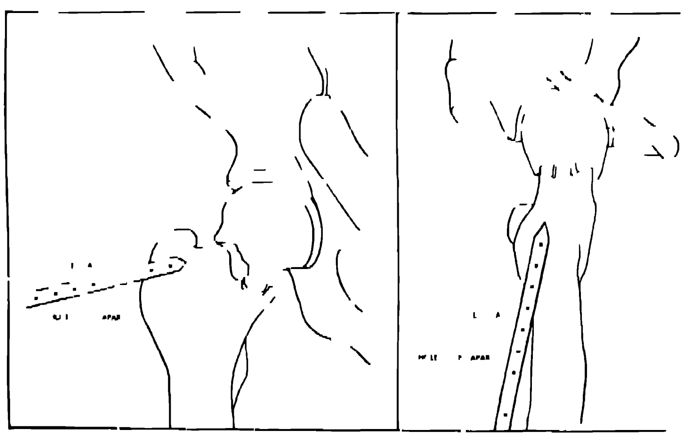


280

Hip Joint and Upper Third of Femur

NECK OF FEMUR
LATERAL (*continued*)

centred obliquely downward between the anterior superior iliac spine and the greater trochanter toward the film **(275, 276, 270)**.

Diagram **(275)** shows the relationship of subject and films for exposure in sequence, with the two X-ray tubes in position, where they remain throughout the operation. As is indicated, the cassette and film pack are removed from the side of the couch remote from the surgeon.

Diagram **(276)**, prepared from tracings taken from radiographs exposed with the film in position, shows the relative position of tube, neck of femur and film for the lateral views.

Radiographs taken by this method show **(271, 272)** the introduction of a bonegraft from the fibula, and **(273)** the graft reinforced by a central single-fin nail.

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*75	40	24	28"	Ilford	Tungstate	

Cone to size of film, 8½ × 6½ in.
* Ward mobile unit.

6. As in the previous method, when the curved cassette is used, the cassette is placed well up into the groin between the legs, with the general plane of the curved surface parallel to the femoral neck. The tube is centred from the lateral aspect of the thigh and directed at right angles to femoral neck and film. The cassette is not so well placed as the film support in **(276)**, but the alignment of the neck is shown satisfactorily.

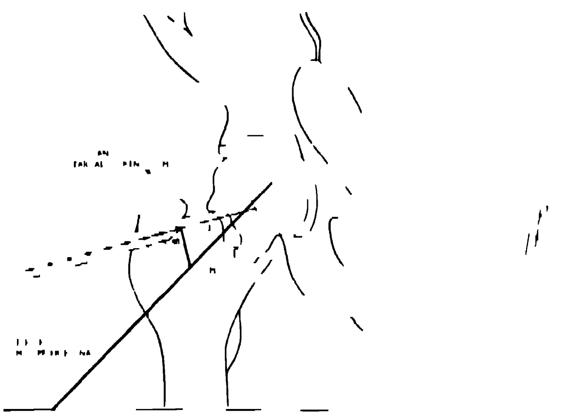
(277, 278)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*70	230	140	30"	Ilford	Tungstate	—
*82	165	100	36"	Ilford	Tungstate	—

Curved Cassette. Cone to size of film, 10 × 8 in.
* Ward mobile unit.

NECK OF FEMUR
OPERATION PROCEDURE

Tracings have been made from a series of radiographs taken before, during, and after the operation for the insertion of the Smith-Petersen nail in the fractured neck



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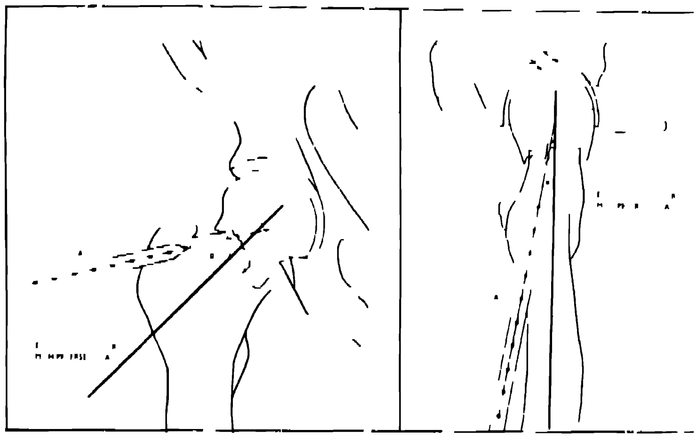

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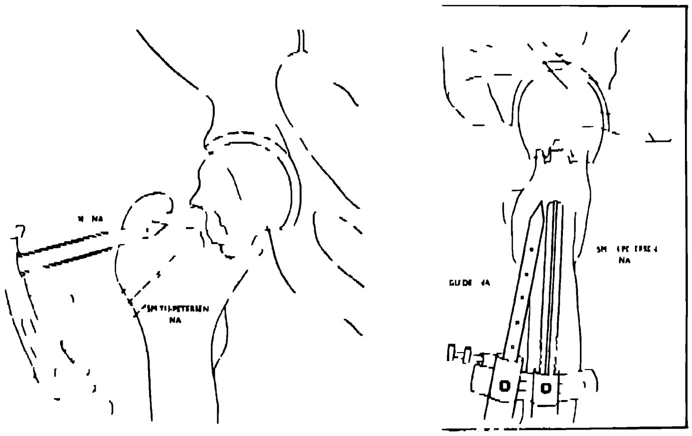
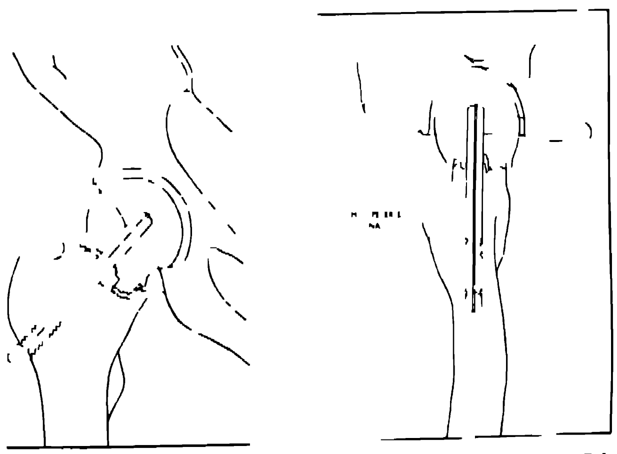


283



284

NECK OF FEMUR

OPERATION PROCEDURE (*continued*)

of the femur. The surgical operation for the insertion of the nail varies considerably, but the principle of determining the direction of the nail is the same throughout, and it is this part of the operation which concerns the X-ray department, especially when the surgeon is dependent during the operation upon the production of radiographs as shown in the illustrations. Some of these are in duplicate in order to include the fullest possible detail of the method of finally adjusting the nail to the correct angle and position, before driving it into the greater trochanter and through the long axis of the neck into the head of the femur. The nail is of stainless steel, triradiate in shape, with three prominent fins.

(279) Tracings from the original radiographs taken in the X-ray department on the patient's way from the casualty department to the ward, before reduction of the fracture.

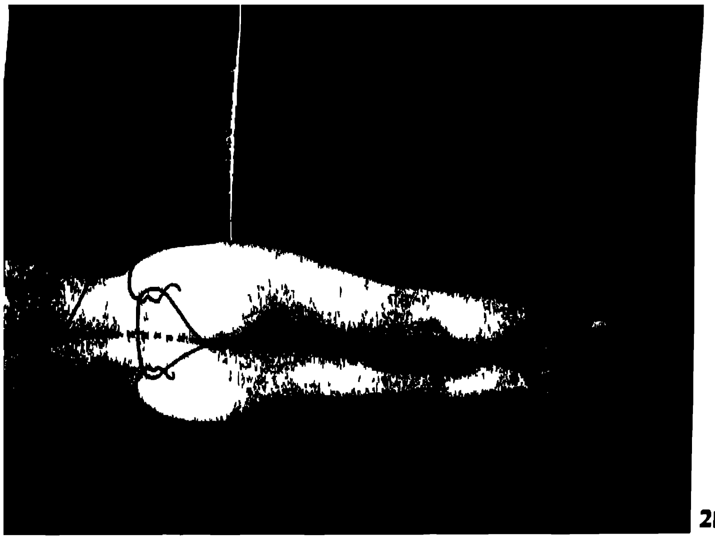
(280) Tracings from radiographs taken in the theatre after reduction of the fracture and the insertion of the guide-nail.

All calculations are made from these films, tracings from which are repeated three times in order to show the calculations step by step. The holes in the guide-nail are one centimetre apart, and as the same degree of enlargement distortion applies to the Smith-Petersen nail, the length of the nail required can be measured in terms of guide-nail centimetres, allowing one centimetre for impaction of the fragments when the nail is finally driven into position.

(281) The best position for the Smith-Petersen nail is selected from both antero-posterior and lateral aspects, and is indicated by a line in the tracings. The angle between this line and the guide-nail is measured—in this instance it is 30 degrees from the antero-posterior aspect and 9 degrees from the lateral aspect.

(282) The next step is to estimate the linear displacement necessary. A perpendicular is dropped from the point of the guide-nail to meet the selected line for the Smith-Petersen nail in both views. This is measured in terms of one centimetre marked on the guide-nail, and constitutes the linear displacement required in each direction when the nail is introduced—in this instance 2 centimetres from the antero-posterior aspect and 7 millimetres from the lateral aspect.

(283) Tracings show the special director, which allows the Smith-Petersen nail to be introduced at the correct angle by applying the result of the previous calculations.



285

286

Hip Joint and Upper Third of Femur

NECK OF FEMUR

OPERATION PROCEDURE *(continued)*

(284) Tracings showing the Smith-Petersen nail finally driven into position.

SUBSEQUENT DEVELOPMENTS

In a later development of this operation technique (1937 to 1943) the guide nail is dispensed with and the calculations are simplified: the special director is fixed rigidly to the operating table, and the length of the incision in the thigh is considerably reduced, but the direction of insertion of the nail is again entirely dependent on the information obtained from progressive X-ray exposures made during the operation.

After reduction of the fracture and fixation of the limbs, the nail sheath of the director is placed against the thigh in the approximate position for the insertion of the nail. From antero-posterior and lateral radiographs, taken on films sufficiently large to include a considerable part of the nail sheath, any necessary adjustment of the director is made on the protractor scales, further radiographs being taken to confirm the accuracy of the adjustment. The incision is made in the thigh, and after the introduction of the nail into the bone another pair of radiographs is taken to show whether the direction has been maintained, in which case the nail is driven home. Final radiographs are taken to show the position of the nail in the head of the femur and in relation to the fracture fragments.

MEDIO-LATERAL

The patient is turned on to the affected side in the true lateral position, with the knees flexed or straight. Soft wool bags are placed between knees and ankles, and sand-bags above and below the pelvis to maintain the patient in position.

CENTRE to the depression over the great trochanter.

(285, 286)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
86	274	166	30″	Ilford	Tungstate	Potter-Bucky
86	264	160	36″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 12 × 10 in. or 15 × 12 in.

NOTE—The kilovoltage is greatly increased. This view gives information regarding the third dimensional position of the stainless steel nail within the head of the femur; and the three fin points of the nail may be localised within the head by one of the methods described in Section 27.

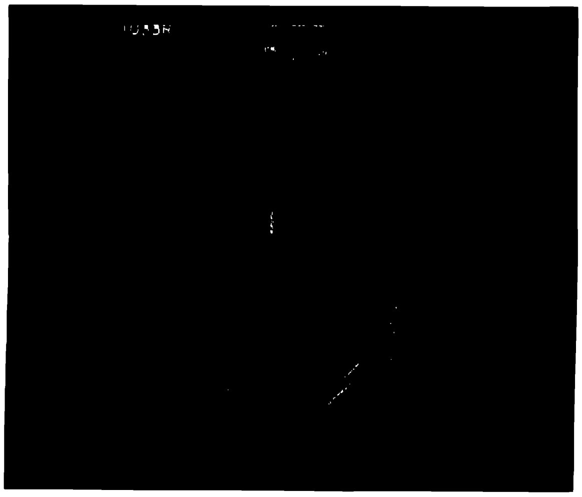
SECTION 5

Pelvic Girdle

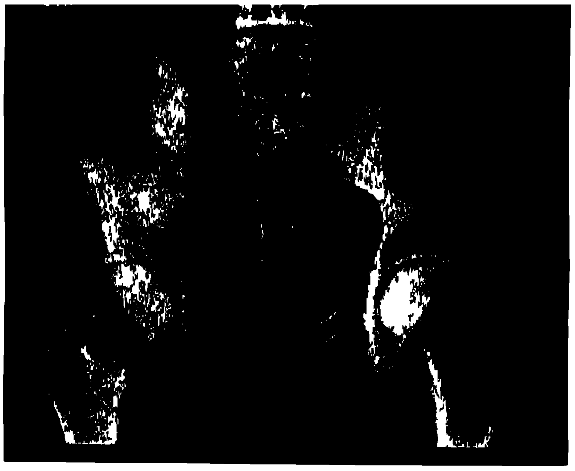
PELVIC GIRDLE

The pelvis or pelvic girdle, in the form of a bony basin, encloses the pelvic organs; it is situated at the lower end of the spine, and serves, through the medium of the hip joints, for the attachment of the lower limbs. The pelvic girdle is formed by the two innominate bones and the sacrum. The innominate bones, which articulate anteriorly, form the sides and front of the pelvic basin, and the sacrum, wedged between the iliac portions of the innominate bones, completes the circle posteriorly, the adjacent surfaces on either side of the sacrum forming the sacro-iliac joints.

There are several bony prominences in the pelvic region which serve as important landmarks in radiography. These, in order of importance, are the symphysis pubis, the anterior superior iliac spines, the iliac crests, the posterior superior iliac spines, the lower sacrum and coccyx, and the ischial tuberosities. The sacro-iliac and hip joints, the symphysis, and the sacral and ischial spines are also important landmarks on the *radiograph*.

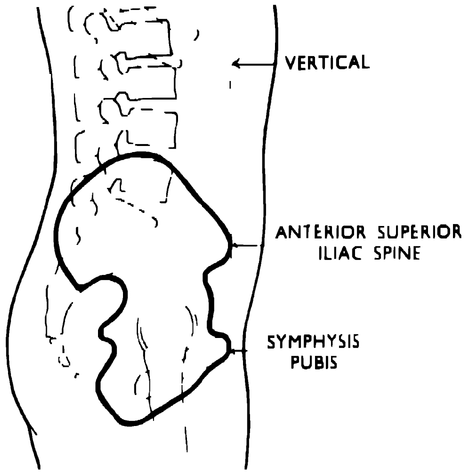


289



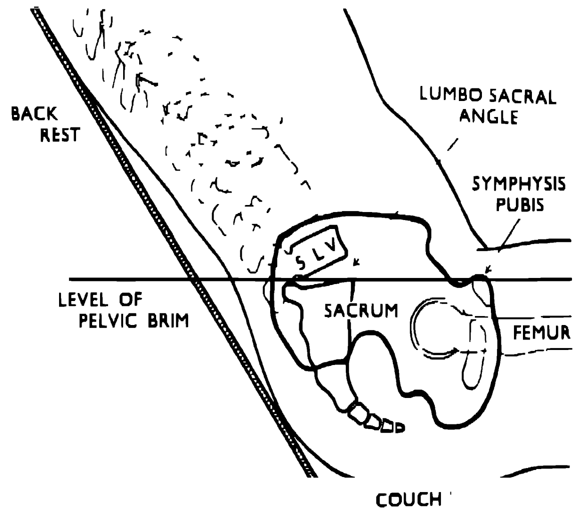
290

When the subject is in the erect position the symphysis pubis and the anterior superior iliac spines are in the same vertical plane **(287)**.



287

When the subject is in the sitting position the pelvic brim (symphysis to lumbo-sacral articulation) is approximately horizontal, and considerable movement of the spine may occur without altering the position of the pelvis **(288)**.

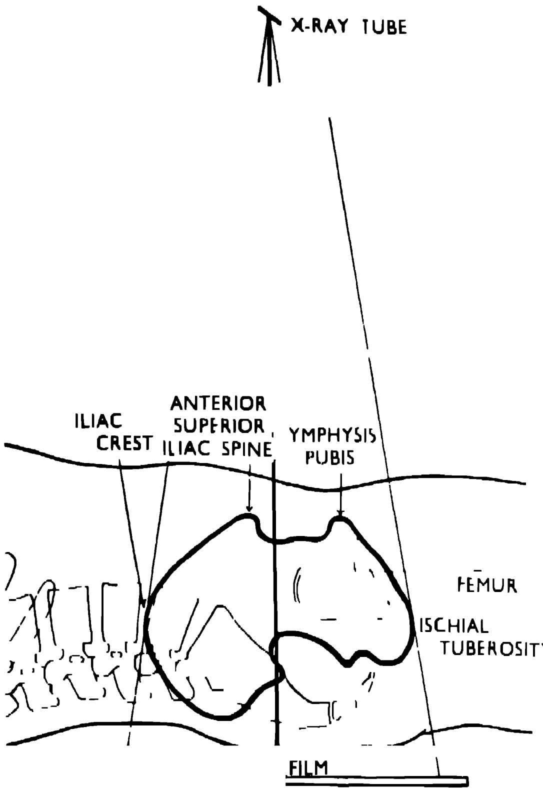


288

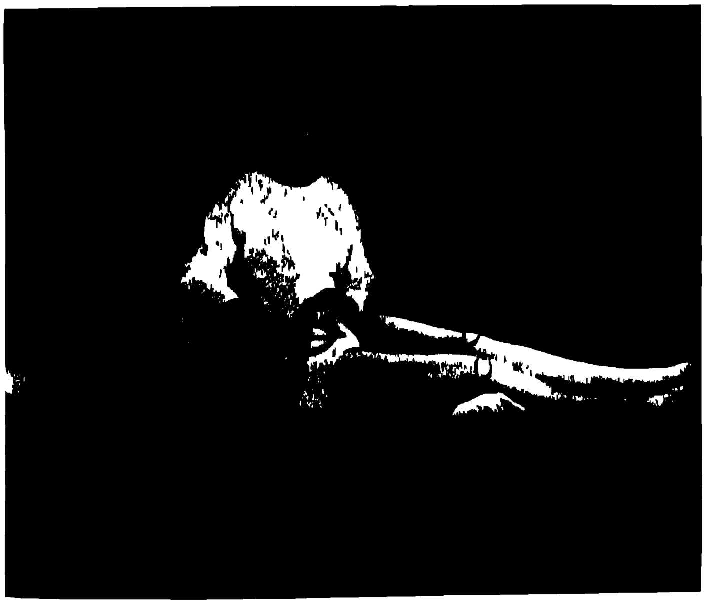
The position of the pelvis when the patient is supine varies with the degree of prominence of the sacrum and extent of lumbar spinal curve, as shown in the two radiographs **(289)** and **(290)**. An intermediate type is shown in **(294)**.

There is a variable difference in the breadth and depth of the pelvis according to the subject type and sex.

The typical female pelvis is broad and shallow, and a 17 inch by 14 inch film is often required to include it in its entirety **(289)**. The typical male pelvis **(290)** is narrow and deep, and is easily included on a 15 inch by 12 inch film as regards width, but careful adjustment may be necessary in order to include both crests and ischial tuberosities. This is particularly the case in short-distance technique, where enlargement distortion is great.



291



292

Pelvic Girdle

The centring point, to include the whole of the pelvis on the film, should be midway between the highest level of the iliac crest and the lowest level of the ischial tuberosity (291), but it is not usually possible or convenient to use these two landmarks. The common error is to centre between the iliac crest and the upper border of the symphysis pubis, resulting in the projection of the lower part of the pelvis beyond the lower border of the film.

As already discussed in the hip-joint section, the pelvis lends itself to considerable distortion, which may be due to bad positioning or to abnormality of the subject. A spirit-level placed across the anterior superior iliac spines will indicate the required adjustment when the pelvis is tilted from side to side. This tilting may be due to a pathological condition giving rise to wasting or swelling on one side. Any difference in level between right and left sides, giving an asymmetrical appearance in the radiograph, may be compensated for by placing a non-opaque pad under one side, the thigh and loin being firmly supported and the spirit-level being used to indicate when the sides of the pelvis are equidistant from the film. Care should also be taken to place the patient centrally to the Potter-Bucky couch and film, and to centre the tube correctly. (292) shows a typical bad position, which in (293) has been corrected.

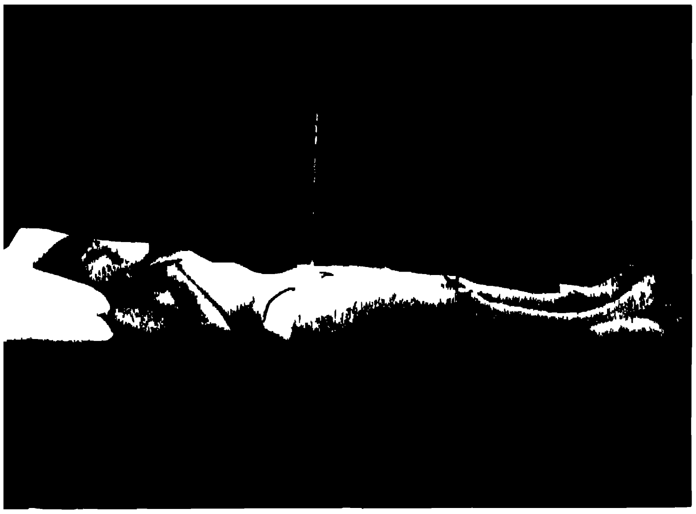
For all examinations of the pelvic region it is preferable for the bowel to be clear of fæcal and gas shadows; suitable preparation, however, is not normally possible in dealing with casualty patients.

The optimum anode-film distance for the antero-posterior view of the pelvis is 36 inches. A greater distance tends to give rise to fading and to grid lines on the outer borders of the film unless the grid is specially designed for the increased anode-film distance.

The exposure factors quoted in this section refer to an adult male subject having a weight of 150 pounds and a height of 5 feet 10 inches.

For smaller or larger subjects the kilovoltage may be varied by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent.

The technique includes antero-posterior, postero-anterior, lateral and oblique views.



293

Pelvic Girdle

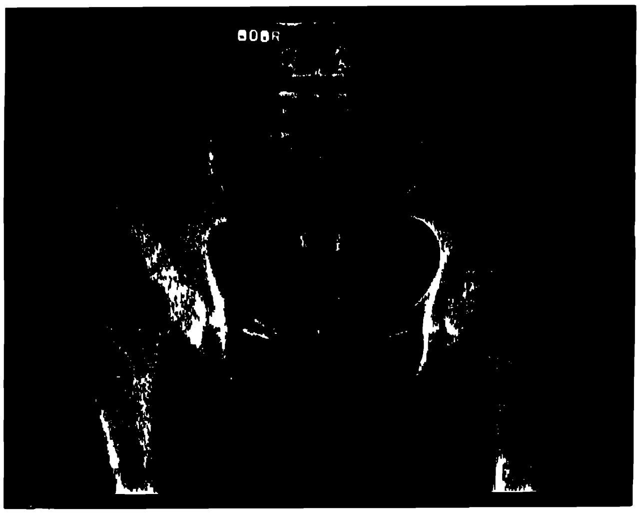
Pelvis

ANTERO-POSTERIOR

The patient is supine, with the knees flexed over a small sandbag, and the feet sandbagged in position as for examination of the hip joints.

CENTRE in the mid-line, half-way between the level of the anterior superior iliac spines and the upper border of the symphysis pubis.

(293, 294)



294

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	35	20	30″	Ilford	Tungstate	—
*70	90	55	36″	Ilford	Tungstate	Stationary
65	132	80	36″	Ilford	Tungstate	Potter-Bucky

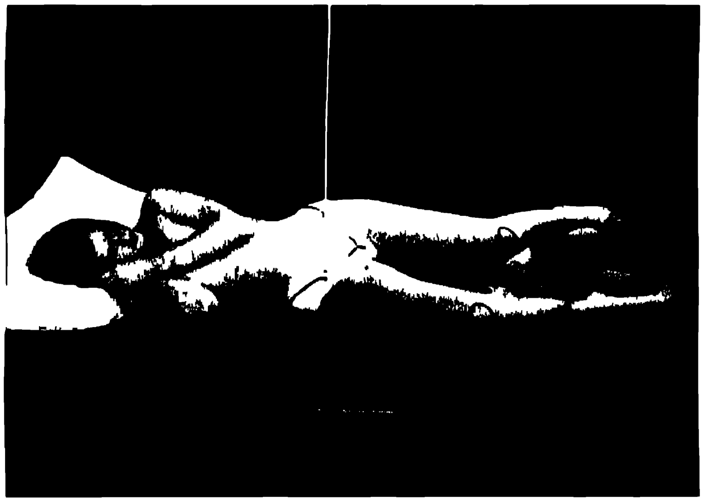
Cone to size of film, 15 × 12 in. or 17 × 14 in.
* Ward mobile unit.

OBLIQUE

The oblique view is taken to show the iliac fossa, the ischium and ischial spine, but it will not be possible or advisable to adjust a badly injured subject to this position.

The patient is turned toward the affected side to bring the iliac fossa parallel to the film, and the raised side of the pelvis is supported on a non-opaque pad, with sandbag support above and below the pelvis. Both knees and hips are flexed, with the raised limb supported at hip level.

CENTRE over the iliac fossa, toward the mid-line of the pelvis, with the film carefully placed to cover the whole of the side of the pelvis in contact with the couch.



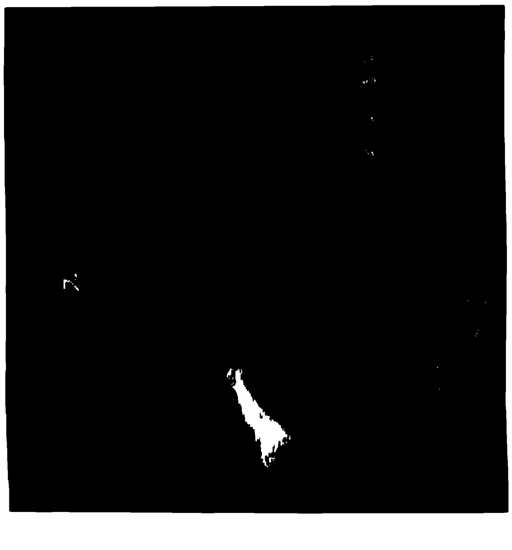
295

(295, 296)

EXPOSURE FACTORS

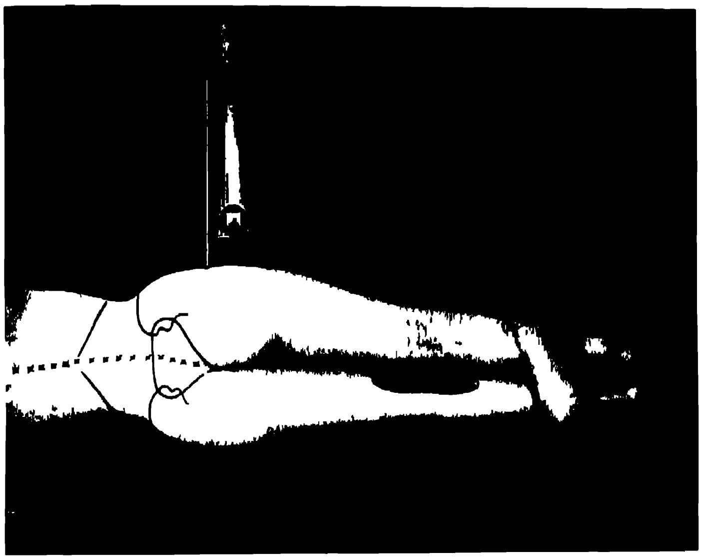
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	87	50	36″	Ilford	Tungstate	Stationary
65	313	190	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 15 × 12 in.

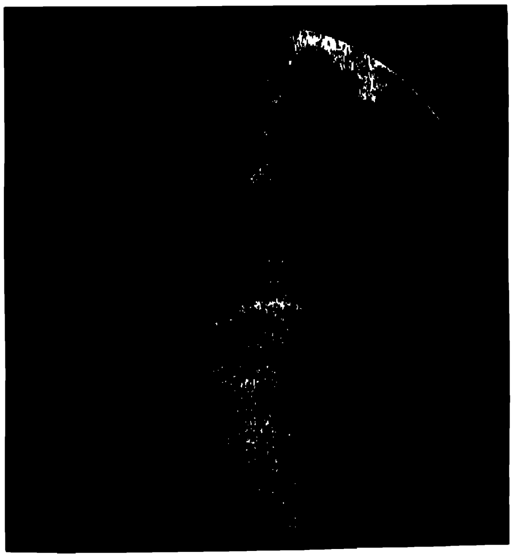


296

297



298



299

Pelvic Girdle: Pelvis

LATERO-POSTERIOR

The patient is rotated until the pelvis is at an angle of 45 degrees to the horizontal, the position being similar to that shown in (295), but with an adjustment in the tube centring.

CENTRE one inch *behind* the anterior superior iliac spine of the raised side.

(297)

NOTE—Since the area examined is at a considerable distance from the film it is essential to use an anode-film distance of at least 48 inches.

EXPOSURE FACTORS						
	mA. Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	340	206	48″	Ilford	Tungstate	Stationary
75	330	200	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in.

This is an unusual position applied in special circumstances when additional information is required regarding the posterior aspect of the iliac bone.

LATERAL

The patient is moved into the true lateral position, with the hips fully extended. This position is maintained by placing sandbags to back and front of trunk and thighs, above and below the pelvis, small pillows being placed between knees and ankles for comfort, as also a pad of cotton-wool between the greater trochanter and the couch.

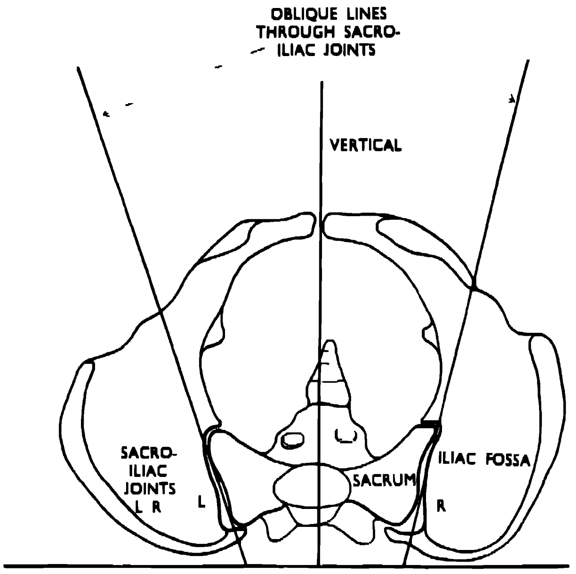
CENTRE above the depression over the great trochanter on the lateral aspect of the thigh.

(298, 299)

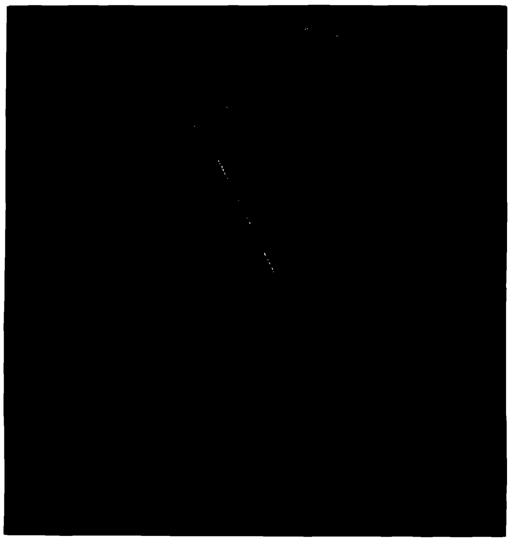
EXPOSURE FACTORS						
	mA Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
86	274	166	30″	Ilford	Tungstate	Potter-Bucky
86	232	160	36″	Ilford	Fluor-azure	Potter-Bucky

Cone to size of film, 15 × 12 in.

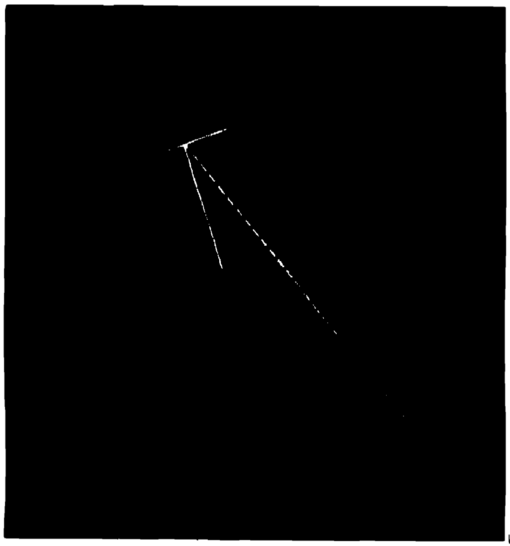
NOTE—When the hips are flexed the symphysis pubis may be obscured by the femora.



300



302

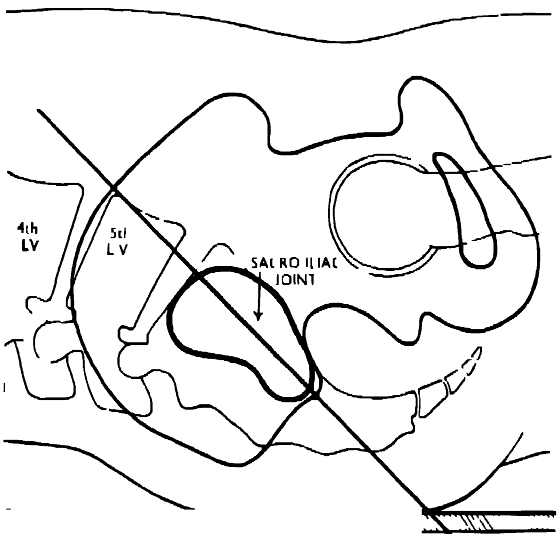


303

Pelvic Girdle

Sacro-iliac Joints

The sacrum is situated between the posterior aspects of the iliac bones, the adjacent surfaces forming the sacro-iliac joints. These joint surfaces are oblique in direction, sloping backward, inward, and downward, necessitating tube angulation to enable the joints to be demonstrated satisfactorily (300, 301).



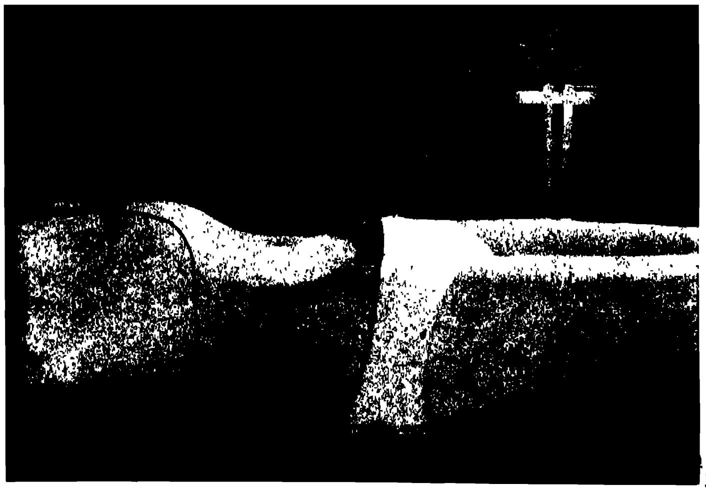
301

The degree of tube angulation for the antero-posterior view requires variation from subject to subject according to type and sex. To illustrate this point two distinctive types are shown in radiographs (302) and (303), in the latter the sacro-iliac articulations being almost horizontal.

In each radiograph a line has been drawn through the long axis of the first two sacral segments, with a second line at right-angles indicating the ideal direction of the X-ray beam, but in (303) this centring cannot be applied, and a third, broken line, showing the restricted angulation of the X-ray beam, indicates that the joints will always appear to be somewhat foreshortened, and therefore distorted, in this type of subject.

As this region is frequently obscured by bowel shadows, suitable preparation of the patient is essential.

Films may be taken in the antero-posterior, postero-anterior, and oblique positions, any or all of which may be stereoscopic.



304

305

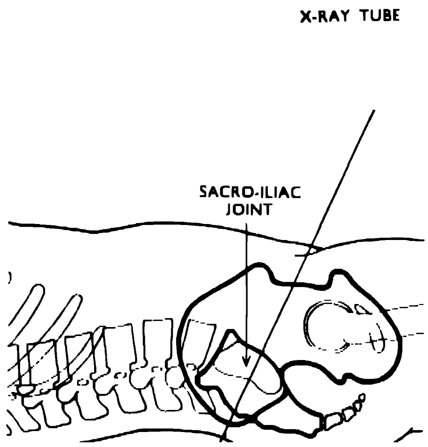
Pelvic Girdle: Sacro-iliac Joints

ANTERO-POSTERIOR

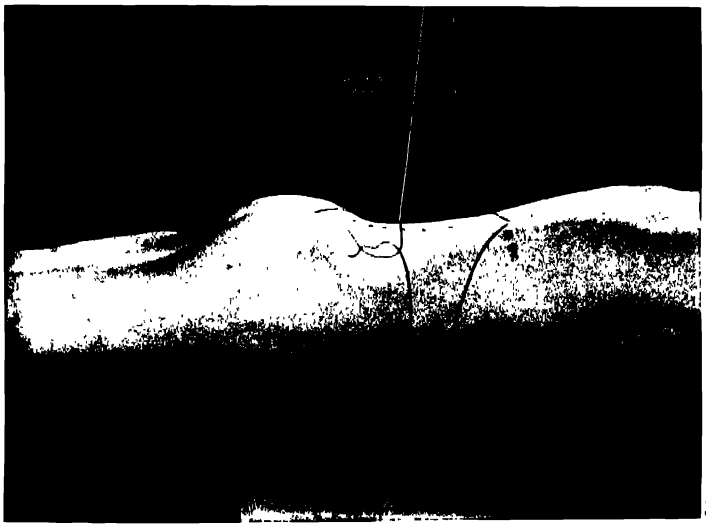
With the patient supine, the shoulders are raised to eliminate the lumbar arch, and the knees are flexed over a small sandbag.

CENTRE above the upper border of the symphysis pubis, with the tube angled 10 degrees to 25 degrees toward the head as required by the degree of lumbo-sacral angulation.

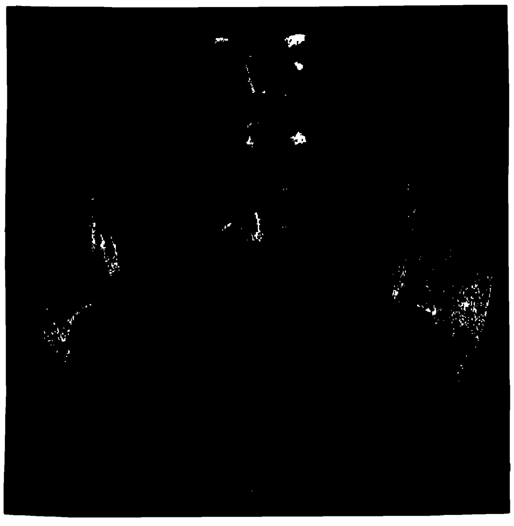
(304, 305, 306)



306



307



308

POSTERO-ANTERIOR

The patient is placed in the prone position, with a sandbag under the ankles.

CENTRE in the mid-line between the dimples of the posterior superior iliac spines, with the tube angled 5 degrees to 15 degrees toward the feet as required.

(307, 308)

NOTE—Films taken in this position show the anterior borders of the sacro-iliac articulation clearly defined. Postero-anterior view **(308)** should be compared with antero-posterior view **(305)**, both of the one subject.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	115	70	36″	Ilford	Tungstate	Stationary
65	165	100	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

Pelvic Girdle: Sacro-iliac Joints

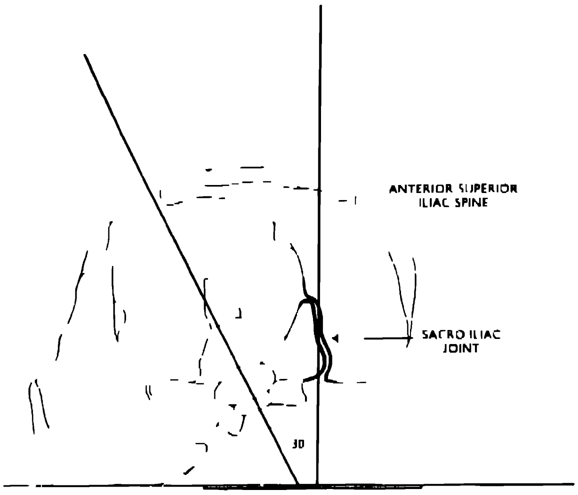

309

OBLIQUE

From the supine position the patient is turned until the antero-posterior axis of the pelvis is at an angle of 25 degrees to 30 degrees to the horizontal, and the pelvis supported on non-opaque pads, with sandbags under the trunk and thigh. Both sides are taken for comparison.

CENTRE one inch medially to the anterior superior iliac spine on the raised side and directly through the joint.

(309, 310, 311, 312)



310

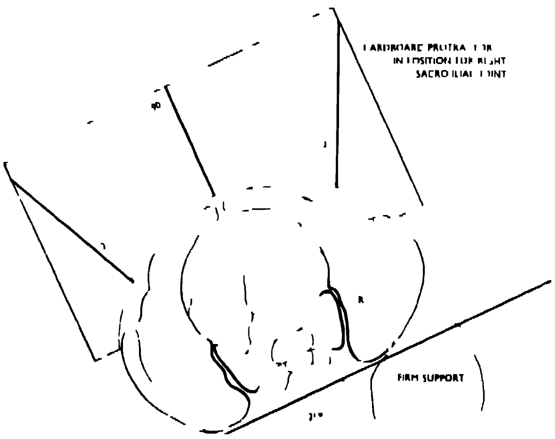
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	154	93	36″	Ilford	Tungstate	Stationary
70	396	240	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

NOTE—A card, cut to the curve of the anterior aspect of the trunk at the level of the anterior superior iliac spines, serves in place of a protractor (313). Three lines are drawn, one centrally, at right-angles to the trunk, and one on each side from a point one inch medially from the anterior superior iliac spine, and at an angle of from 25 degrees to 30 degrees to the central line, these two angled lines representing the direction of the articular surfaces. The patient is rotated with the protractor in position until the angled line is vertical for each side in turn (313). The resulting films show a clear antero-posterior joint space (311, 312).

311

312



313

SECTION 6

Spine

SECTION 6

SPINE

The spine forms a series of curves extending from the base of the skull to the level of the hip joints, and in addition to the variations found in abnormal patients, such as kyphosis and scoliosis, the normal spinal curves vary from subject to subject. Individual consideration is therefore necessary.

It is essential, also, to consider the position of adjacent bone structures, such as the lower jaw overhanging the upper cervical vertebræ, the oblique line of the ribs from posterior to anterior aspect, and the downward tilt of the pelvis, the importance of which will be apparent on reference to the photographs of the skeleton (**315, 316, 317**).

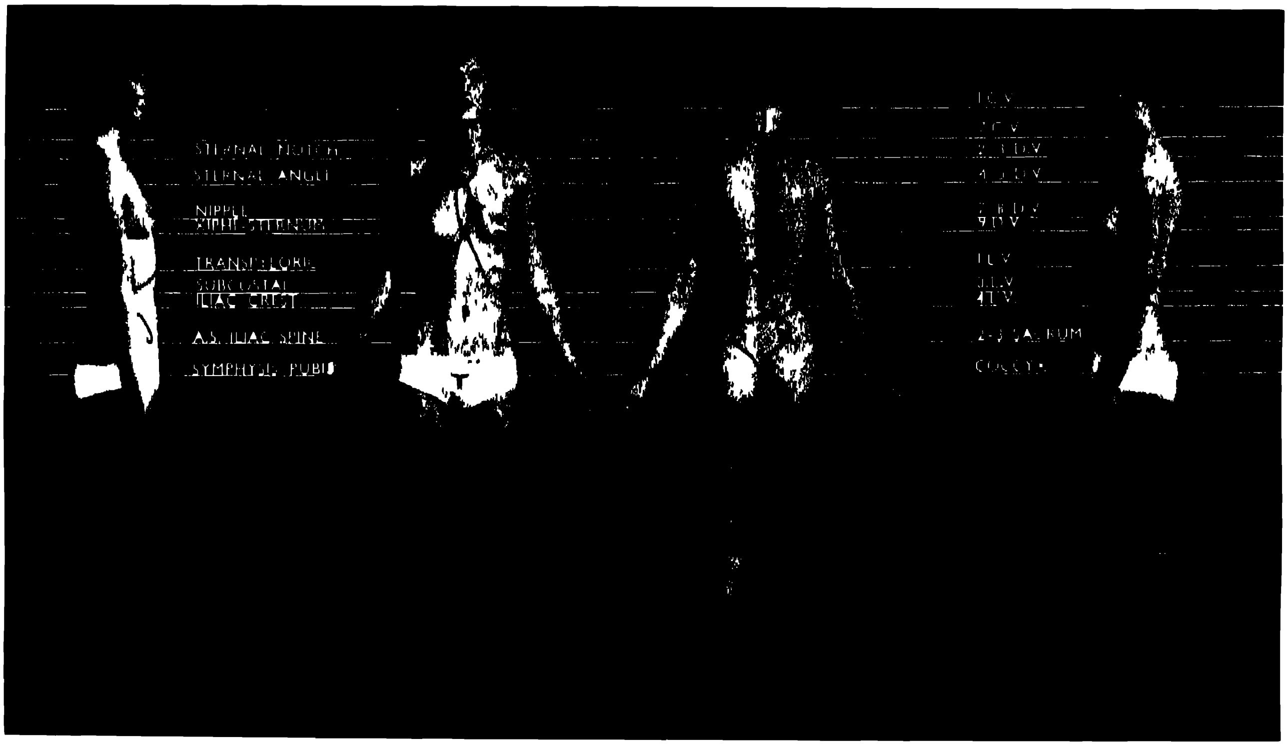
There is often some confusion as to the relationship between certain anatomical landmarks in anterior, posterior and lateral aspects of the trunk: resulting radiographs show this only too clearly, especially in the various regions of the spine. In the accompanying illustrations of the full-length figure (**314**), the levels of the important comparative landmarks are indicated. These are also shown in the diagram (**318**).

The recognised views for the spine are the antero-posterior and lateral, with sometimes oblique and postero-anterior views. Where the natural posture is required films are taken in the erect position; otherwise the patient is horizontal, and the adjustment between spine and film is carefully studied in order to obtain a clear view of the intervertebral articulations. The examination may be general or localised.

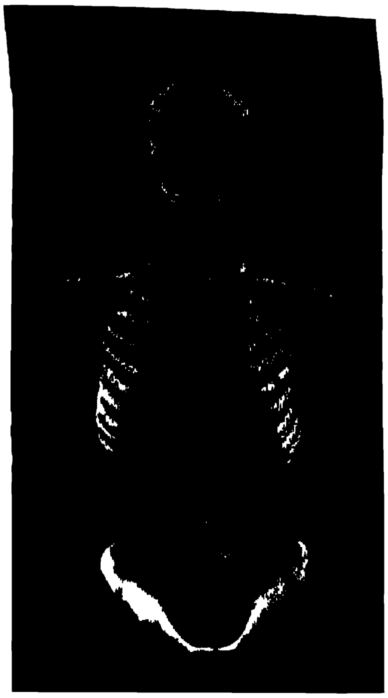
The complete spine is sometimes radiographed from either antero-posterior or lateral aspects during a single exposure on a film 24 inches or more in length, the patient maintaining a natural posture in the erect attitude for the lateral view so that general relationships may be shown. Unless, however, special equipment is available, it is obvious that a single exposure cannot give a satisfactory film of the whole of the spine, and it may, in addition, be necessary to radiograph each region separately for local detail, using the appropriate exposure factors.

For convenience the spine, from occipito-cervical articulation to coccyx, is divided into localised regions according to radiographic density and anatomical peculiarities These, in anatomical order, and together with positions applied for radiography, are as follows:—

Occipito-cervical articulation:	Antero-posterior. Postero-anterior. Lateral. Oblique.
Cervical spine:	Antero-posterior, 1 -3. Antero-posterior, 2—7. Lateral, 1—7.
Cervico-dorsal region:	Antero-posterior. Lateral. Oblique.
Dorsal spine:	Antero-posterior. Lateral.
Lumbar spine:	Antero-posterior. Postero-anterior. Lateral. Oblique.
Lumbo-sacral articulation:	Antero-posterior. Postero-anterior. Lateral. Oblique.
Sacrum:	Antero-posterior. Lateral.
Coccyx:	Antero-posterior. Lateral.

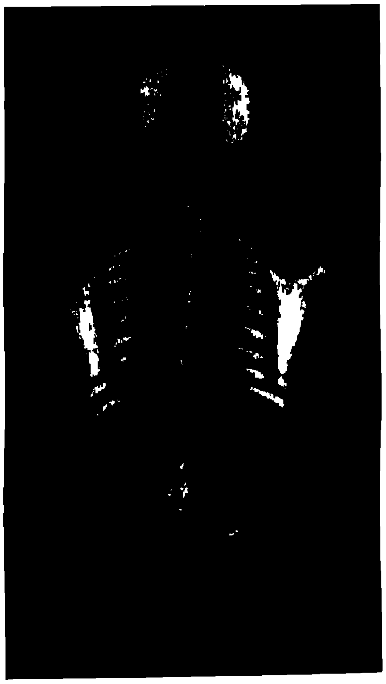


314



315

316



Spine

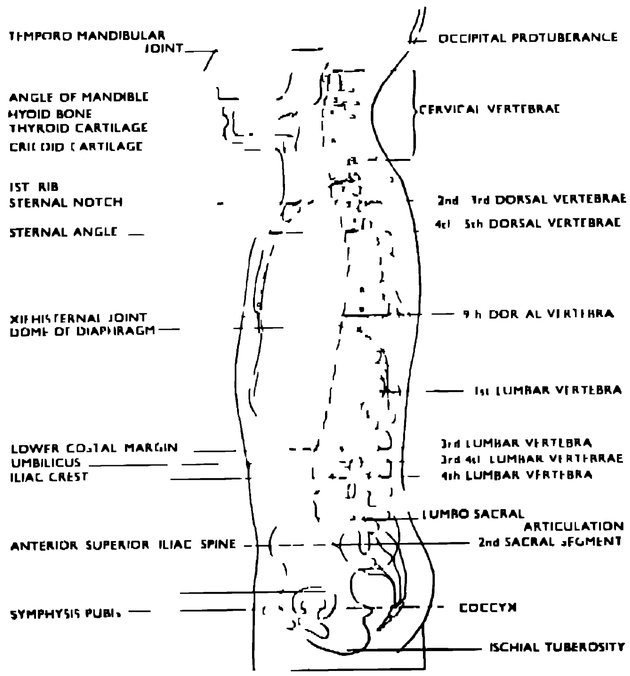
Although many of the spine subjects can be dealt with as illustrated in the text, gross injuries, especially in the cervical region, require a modified technique, it often being necessary to carry out the entire examination without moving the patient. It is not difficult to arrange this when a modern ward mobile unit is available or when the over-couch tube can be moved freely on the vertical stand.

Advice from the medical officer in charge of the case will decide the advisability of viewing antero-posterior radiographs before moving the patient into the lateral position. Many casualty trolleys are built in such a way that the metal side supports sustaining the curved stretcher, whether metal or canvas, prevent the taking of a lateral view unless the patient is moved from the *supine* position, but with the patient in the *prone* position postero-anterior and lateral views can be taken without the necessity of movement. The stationary grid is an asset in these cases.

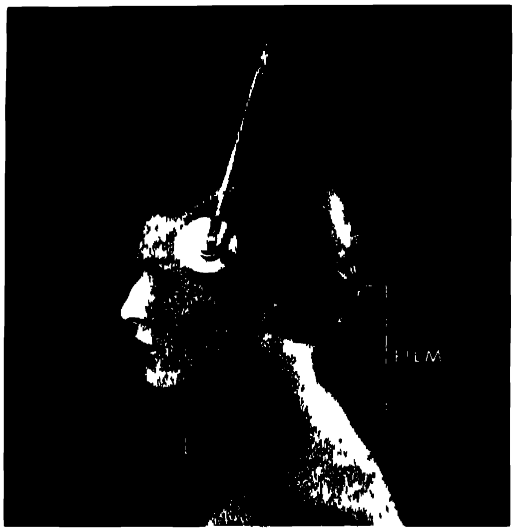
Apparatus manufacturers are now interested in this very important problem of taking satisfactory radiographs of the trunk without moving the patient. Units are available which allow the tube and grid to be adjusted to the patient from every aspect, provided, of course, a suitable stretcher-trolley is available. X-ray equipment of the future should provide for the special X-ray stretcher trolley.

The exposure factors quoted in this section refer to an adult male subject weighing 140 pounds and having a height of 5 feet 8 inches.

For smaller or larger subjects the kilovoltage may be varied by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent.

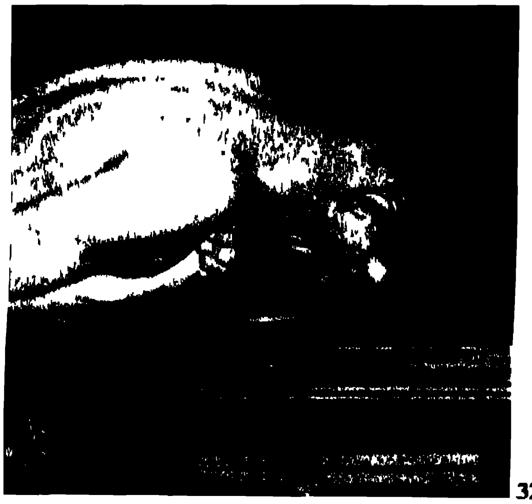


318



319

320



321

322

Occipito-cervical Articulation

This region is now receiving considerable attention, and requests for X-ray examination are increasingly frequent. It is difficult to obtain satisfactory radiographs consistently, as the general plane of the articular surfaces is parallel to the curved surface of the occipital bone and in such close proximity as to minimise the possibility of dissociating the two regions by projection. Variations in the position of the head, however, from antero-posterior and postero-anterior aspects, allow overshadowing of the lesser facial densities. It is essential to remove all opacities such as artificial dentures, hair pins, and neck and ear ornaments.

LATERAL

The patient is placed with the head and upper part of the neck in the true lateral position, with the cassette in contact with the lateral aspect of the neck.

CENTRE one inch below the external auditory meatus and toward the first cervical vertebra, using a small localising cone. (319, 320)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	33	20	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in.

NOTE—The demonstration of a clear joint space in this position depends entirely on the degree of transverse curve of the articular surfaces. See (322, 323, 325, 326).

POSTERO-ANTERIOR (1)

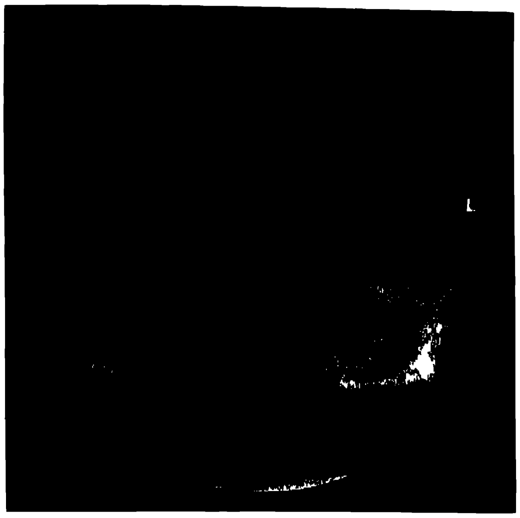
The patient is placed facing the film, with the nose and forehead in contact with the couch or film support, and with the line between the external auditory meatus and the outer canthus of the eye (base-line) at right-angles to the film.

CENTRE through the nape of the neck, toward the antra. (321, 322)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	50	30	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in.

NOTE—The occipito-cervical articulations are shown, one side through each antrum. The exposure should be considerably reduced as compared with the antra exposure from the same aspect.



323

324

325

Spine: Occipito-cervical Articulation

POSTERO-ANTERIOR (2)

With the head in the same nose-forehead position (321), a cork of suitable size is placed between the jaws to keep the mouth wide open

CENTRE one inch below the occipital protuberance, with the tube angled toward the open mouth (323)

The occipito-cervical articulations are clearly shown between the shadows of the maxillæ and mandible It is not always possible to project the articulations clear of the upper teeth, the position, however, is particularly satisfactory in the *edentulous* subject

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	33	20	30	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in

ANTERO-POSTERIOR OBLIQUE

With the patient facing the tube, the head is placed with the base-line at right-angles to the film

After CENTRING *between* the orbits, the head is rotated until the central ray is *over* right and left orbit in turn, making an exposure in each position for comparison. The occipito-cervical articulations are well demonstrated, and, in addition, the odontoid process is very clearly shown.

(324, 325, 326)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	40	25	30	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in

327

328

329

330

Spine

Cervical

Three general *routine* positions are used, a general lateral and two antero-posterior, in the latter vertebræ one to three being taken through the open mouth and vertebræ two to seven from below the mandible.

These radiographs include the seven cervical vertebræ, the occipito-cervical and the cervico-dorsal articulations. Intensifying screens are used, but all views may be taken with or without the grid, in either the erect or the horizontal position.

Prior to the examination it is essential to remove all opacities such as artificial dentures, ear-rings, hairpins, clips and neck ornaments. The patient is bared to the level of the axillæ.

ANTERO-POSTERIOR

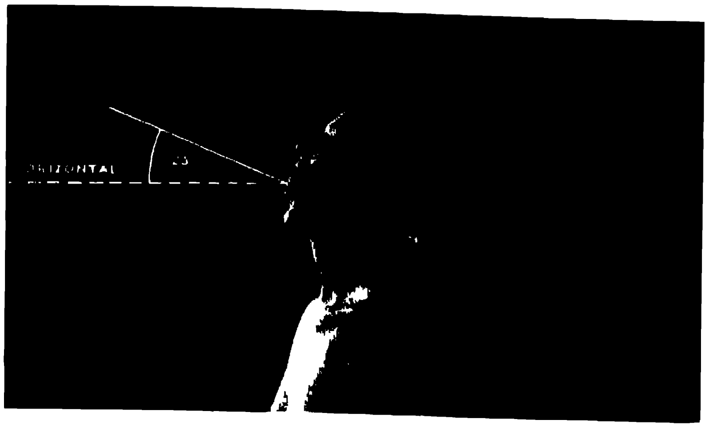
In the illustrations the antero-posterior views are shown with the patient in the erect position; by turning the illustrations clockwise through 90 degrees the horizontal positions will be seen. The condition of the patient indicates the choice of method, but immobilisation is more satisfactorily obtained with the patient on the couch.

The position of the bones should be carefully located before making the first exposure. From the prominent seventh cervical vertebra the spinous processes up to the third and second can be felt and the level of these bones seen from the lateral aspect of the neck. The level of the angle of the jaw will be found to coincide with the second to third cervical vertebræ. The relationship of the occipital protuberance and the spine should be noted, also the variable relationship of the open mouth and hard palate with the first and second cervical vertebræ as the head moves backward and forward on the spine.

FIRST—THIRD VERTEBRÆ

The patient is placed facing the tube and the head adjusted so that when the mouth is wide open it is exactly opposite the first and second cervical vertebræ. The head is maintained in position with sandbags when horizontal, or with the head clamp in the erect position.

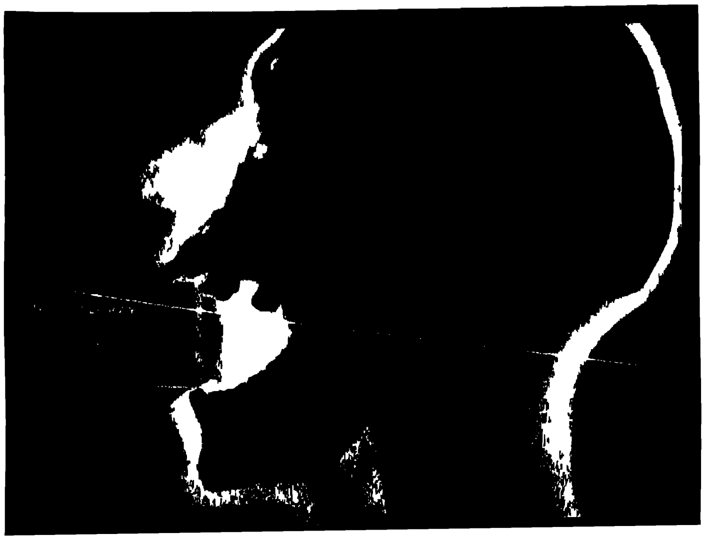
Opening and closing the mouth does not alter the relationship between upper jaw and spine, so that the patient need not be kept in discomfort during final adjustments before the exposure is made. A cork, the largest that can be used without discomfort, placed between the jaws steadies the patient in addition to preventing the mouth from gradually closing during the exposure.



331

332

333



Spine: Cervical

ANTERO-POSTERIOR FIRST—THIRD VERTEBRÆ

CENTRE through the open mouth, parallel to the hard palate and toward the first and second cervical vertebræ. In the radiograph the upper jaw and occipital bones obscure each other; below are the first, second and third cervical vertebræ (328): in the edentulous subject the fourth may be included (329), but the spine below this level is obscured by the lower jaw.

(327, 328, 329)

EXPOSURE FACTORS

kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	33	20	30″	Ilford	Tungstate	–
65	65	40	30″	Ilford	Tungstate	Potter-Bucky

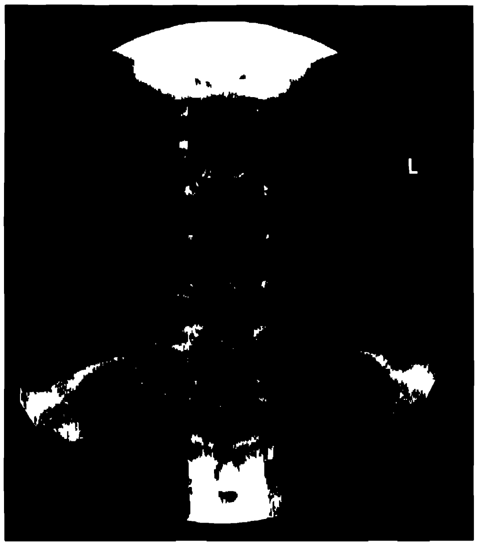
Cone to size of film, 6½ × 4¾ in

A 24 inch to 30 inch anode-film distance is preferable to a greater distance, as the shorter divergent rays permit the inclusion of more vertebræ through the narrow aperture between the jaws.

NOTE—A stiff neck, with the head flexed forward or extended backward, will tend to cause either the upper jaw or base of skull to obscure the first and sometimes the second vertebra. In such a case the tube is angled toward the head when the spine is flexed (330), or toward the feet when the spine is extended (331), a direct line being maintained through the open mouth to the atlas and axis. A further check on the correct position is the parallel between the X-ray beam and the hard palate.

To assist in identifying the position of the bones within the soft structures of the neck, two films have been exposed in a single cassette, one between the intensifying screens to show the bones, and (333) in front of, and, therefore, unaffected by, the screens to show the soft tissues. After obtaining a contact positive transparency of the bone film (332), this was placed over the negative soft tissue film to produce the effect shown in (334) and the tube angle indicated for the antero-posterior view.

335



336

337

Spine: Cervical

ANTERO-POSTERIOR SECOND—SEVENTH VERTEBRÆ

The patient is placed with the head in position so that the lower jaw and the posterior base of the skull are in the direct line of the oblique ray, and so obscure each other in the shadows on the radiograph.

In the long-necked subject it may be possible to include the seven vertebræ, but usually the upper two are obscured by the lower jaw.

CENTRE above the sternal notch, at the level of the second dorsal vertebra.

(335, 336)

EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*55	28	17	36″	Ilford	Tungstate	—
*65	38	23	36″	Ilford	Tungstate	Stationary
65	66	40	48″	Ilford	Tungstate	Potter-Bucky

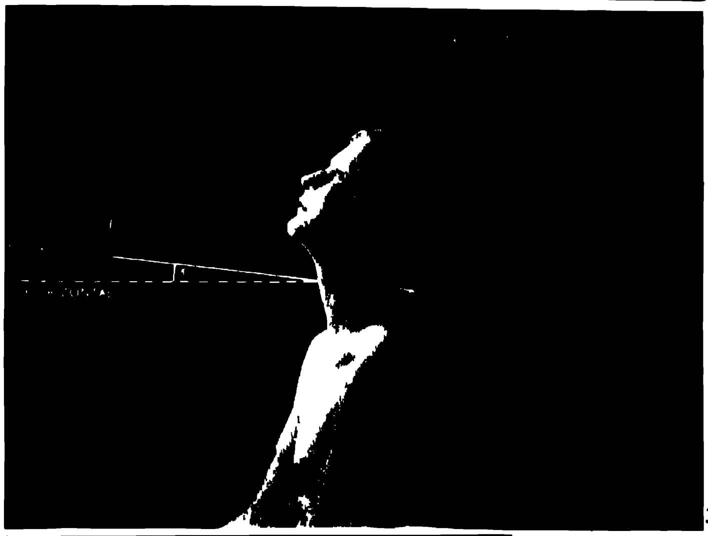
Cone to size of film, 8½ × 6½ in. or 10 × 8 in.
* Ward mobile unit

The divergent beam passing through the lower jaw and occipital region allows a greater number of the cervical vertebræ to be included. This is illustrated in the lateral radiograph (337), which has been lined to show the direction of the axial and oblique rays from the antero-posterior aspect.

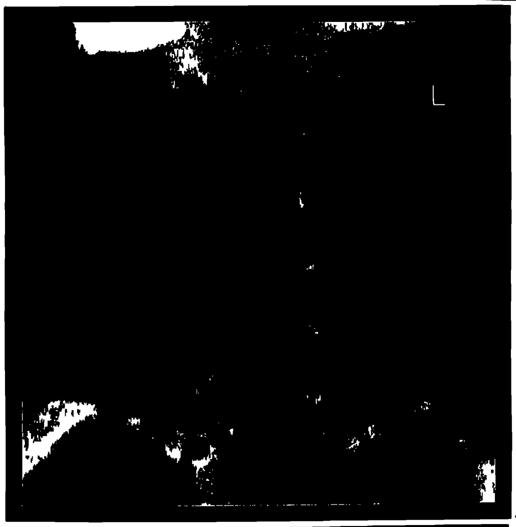
Alternatively, to improve definition the tube may be angled 10 degrees toward the head, allowing a smaller localising cone to be used (338).

NOTE—There is a tendency to over-extend the head, it being overlooked that the occipital bone is then projected downward to obscure the upper vertebræ (338a).

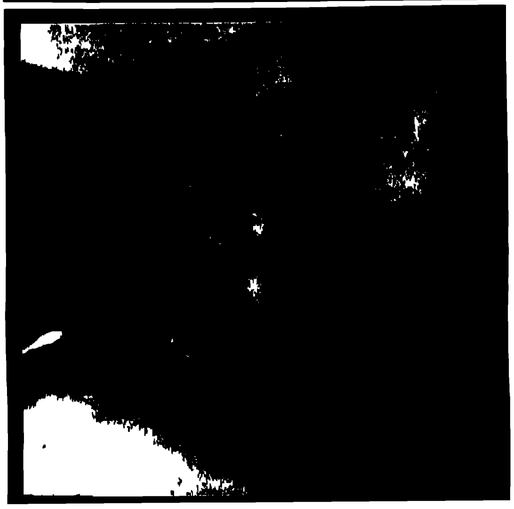
338



338a



339



339a

Spine: Cervical

ANTERO-POSTERIOR
SECOND—SEVENTH VERTEBRÆ *(continued)*

When there is difficulty in adjusting the head to the ideal position, the tube is angled toward feet or head as required.

A stiff neck, in a flexed position, is particularly difficult to deal with, and the horizontal position is preferable. The tube is angled toward the head, as shown in **(338)**, in order to project the lower jaw to the highest possible level.

Additional projections through the open mouth may sometimes include the area to be covered, or stereoscopic views from lateral and oblique aspects may complete the information required by the radiologist.

Excessive extension of head and neck, as in **(338a)**, will project the occipital bone over the upper cervical region, and it is then necessary to angle the tube toward the feet.

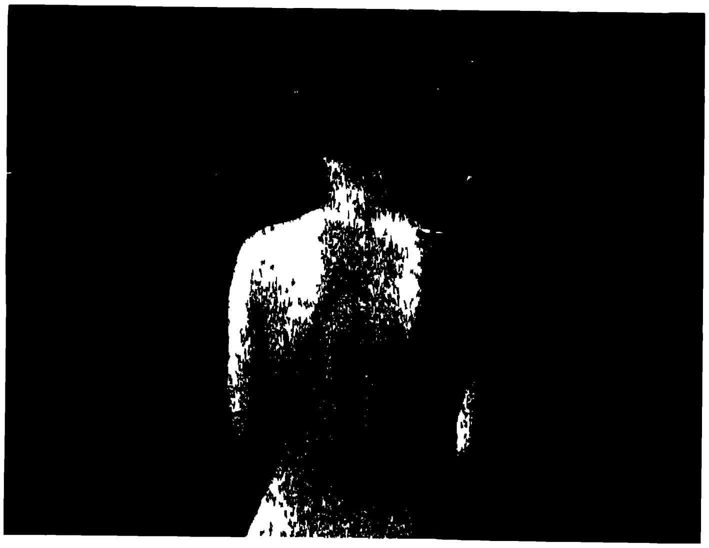
By turning the illustrations clockwise through 90 degrees the patient may be seen as in the horizontal position.

For horizontal work the curved cassette fits into the posterior curve of the neck, thus assuring immobilisation as the patient rests comfortably on the cassette, and at the same time the spine-film distance is reduced, definition being thereby improved.

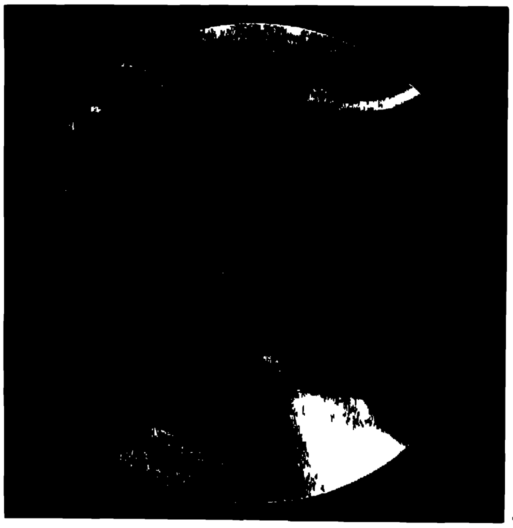
FRACTURE RADIOGRAPHS

Two radiographs show a fracture-dislocation in the fifth cervical region and serve to confirm the importance of the lateral view. Both views were taken with the patient in the supine position **(346)**.

340



341



342

Spine: Cervical

LATERAL

This view embraces from the occipito-cervical articulation to the second and sometimes the third dorsal vertebra.

The patient may be seated or, preferably, standing, in the lateral position in relation to the film. The neck is extended and the jaw slightly raised so that the angles of the mandible are separated from the cervical bodies, the shoulders being depressed so that their dense structures are projected below the level of the seventh cervical and first to third dorsal vertebræ. The posture shown in (340) allows the patient to feel confidence and steadiness; or one forearm may be placed across the abdomen anteriorly and the opposite forearm posteriorly, with the elbows unsupported.

The head is maintained with the median plane parallel to the film and the transverse plane of the face at right-angles to the film.

The film is placed on the lateral aspect of the shoulder and, therefore, some considerable distance from the spine. To compensate for the *subject*-film distance, which would give rise to considerable distortion, the *anode*-film distance is increased to a minimum of 60 inches.

Immobilisation is important: this may be secured by using a head clamp, or by the use of a non-opaque pad between head and film or a sheet of cardboard fitted to the crown of the head to allow pressure against the film at the correct distance.

CENTRE to a point approximately one inch behind the angle of the mandible, over the second to third cervical vertebræ.

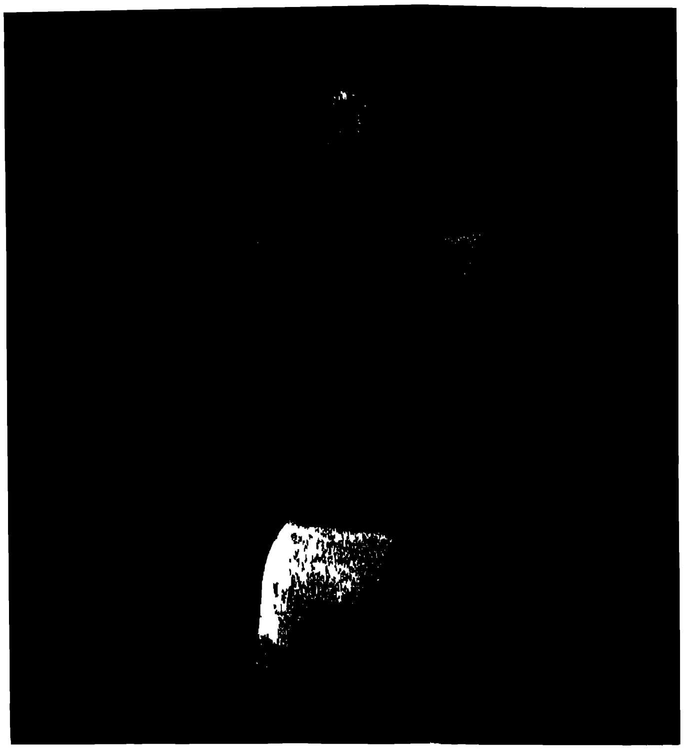
(340, 341, 342)

EXPOSURE FACTORS

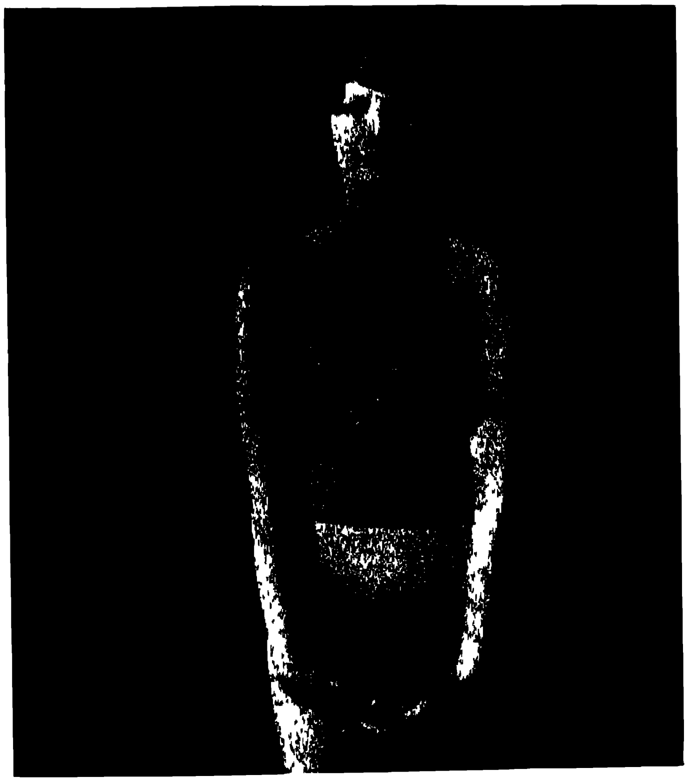
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	38	23	60″	Ilford	Tungstate	—
65	100	60	60″	Ilford	Tungstate	Potter-Bucky
65	140	86	72″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

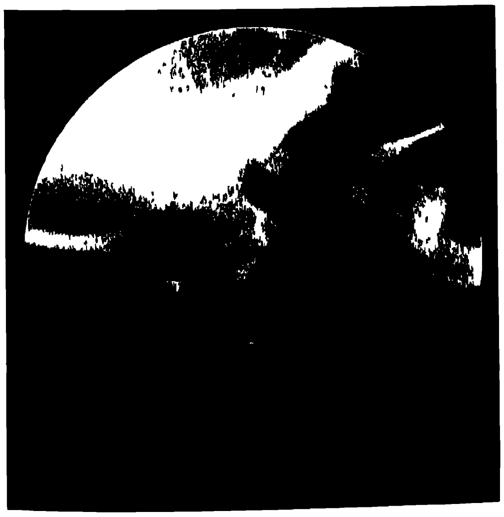
In the absence of a vertical stand for teleradiography it is usually possible to arrange for a temporary film support, suitably placed, to allow the X-ray tube to be rotated to project the beam horizontally toward the neck.



343



344



345

Spine: Cervical

LATERAL ***(continued)***

Figures (343, 344) show the difference between the levels of the shoulders when the arms are folded across the chest, allowing the shoulders to hunch upward, and when the arms hang straight from the shoulders, with the hands clasped at their lowest level, allowing the shoulders to drop free of the lower cervical region. In this latter posture the head tends to strain upward against the downward pull of the shoulders and is ideal for lateral cervical technique when the patient is able to stand.

When apparatus limitations prevent horizontal projection of the beam, and providing his or her condition permits, the patient is rotated on to one side, with the shoulders, especially the lower, depressed to the lowest possible level, and the head supported on a padded wood block so that the cervical and upper dorsal spine is parallel to the film.

The upper five cervical vertebræ may be taken with the film in contact with the neck, using a short anode-film distance. This method is applied when only the upper five vertebræ are required (345).

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	10	6	30″	Ilford	Tungstate	—
65	20	12	30″	Ilford	Tungstate	Stationary

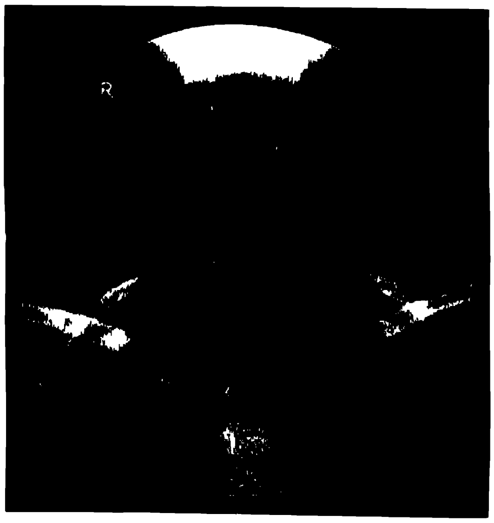
Cone to size of film, 10 × 8 in.

The use of the curved cassette adds greatly to the patient's comfort in these circumstances, and for the upper five cervical vertebræ satisfactory results are obtained, but there is considerable distortion of the cervico-dorsal region.

346

347

348



349

Spine: Cervical

LATERAL *(continued)*
STRETCHER PATIENTS

It is frequently necessary to radiograph the patient in the horizontal position on the stretcher trolley. In these circumstances, with the patient supine, the film is supported in the vertical position lateral to the spine at shoulder level, and, using the ward mobile unit, the X-ray beam is directed horizontally from a 60-inch anode-film distance. Reference should be made to radiographs (339, 339a) showing a fracture-dislocation in the fifth cervical region.

(346, 347)

EXPOSURE FACTORS						
	mA. Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	38	23	60″	Ilford	Tungstate	—
*65	104	63	60″	Ilford	Tungstate	Stationary

Cone to size of film, 10 × 8 in or 12 × 10 in.
* Ward mobile unit

Cervico-dorsal Region

This region embraces from the fifth cervical to the fourth dorsal vertebra.

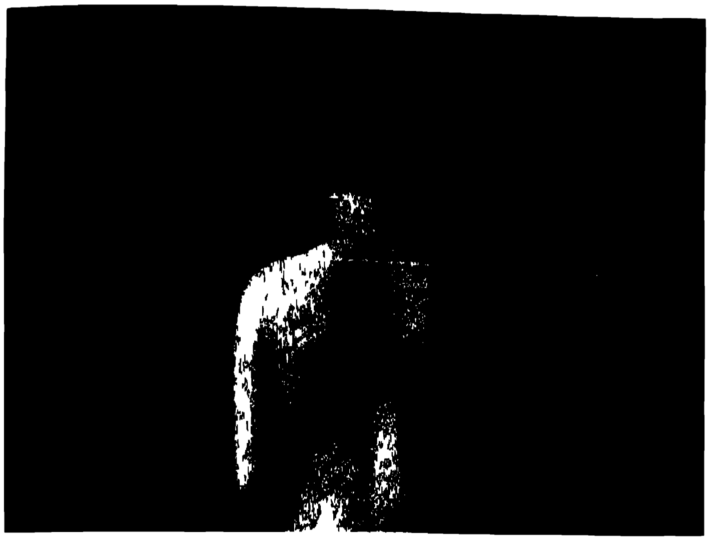
From the lateral aspect this is the most difficult region of the spine to radiograph, as the dense shoulder structures obscure the vertebræ, especially in the short-necked, hunch-shouldered type of subject. It is a region frequently sent for X-ray examination, and is almost as frequently inadequately demonstrated.

ANTERO-POSTERIOR

The technique is similar to that applied for the antero-posterior view of the third to seventh cervical region. The film is placed in position to include from the fourth cervical to the fourth dorsal vertebra. From this aspect the radiographic density of both cervical and upper dorsal region is the same, due partly to the overshadowing of the air-filled trachea, so that satisfactory radiographs are obtained.

CENTRE above the sternal notch.

(348, 349)



350

351

351a

Spine: Cervico-dorsal Region

ANTERO-POSTERIOR *(continued)*

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	19	12	36″	Ilford	Tungstate	–
70	26	16	36″	Ilford	Tungstate	Station-ary
70	66	40	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

LATERAL

The same technique is applied as for the lateral view of the cervical spine.

Either horizontal or erect positioning is used, according to the condition of the patient. Special care should be taken to see that the shoulders are depressed to the lowest possible level, applying one of the postures previously described, the subject being immobilised with care.

CENTRE to the lateral aspect of the neck at the level of the second to third cervical vertebræ.

(350, 351)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	140	86	72″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.

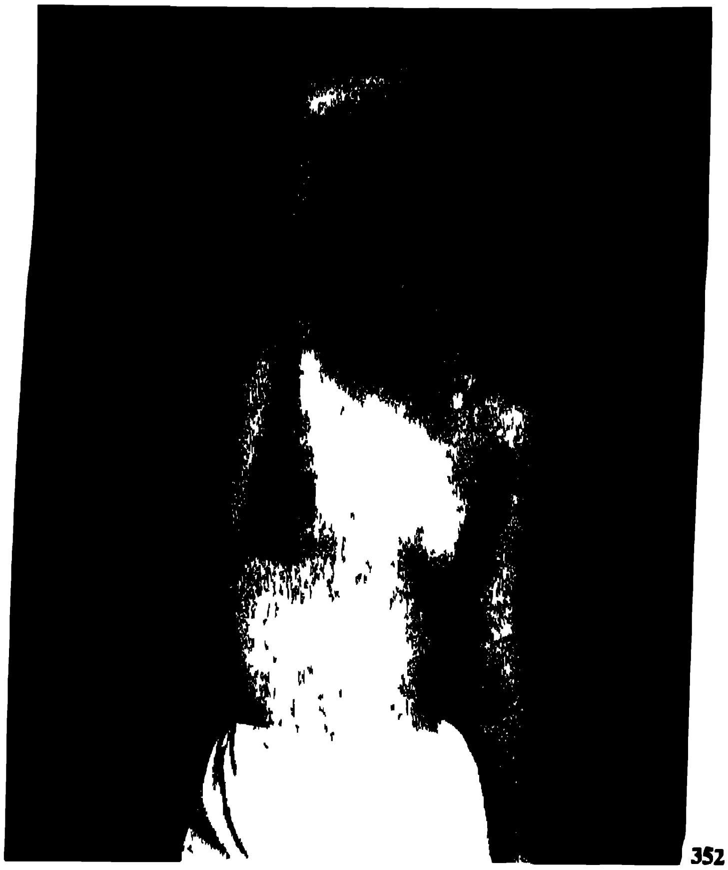
In suitable long-necked subjects the first, second and sometimes the third dorsal bodies are shown in the radiograph, but in many subjects it is necessary to take other views, described in the following pages.

SPINOUS PROCESSES

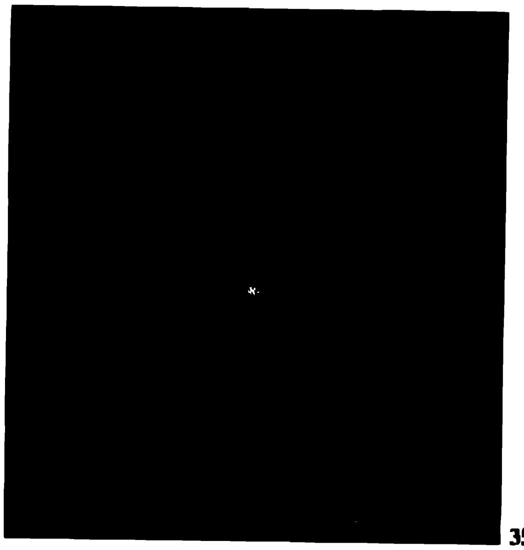
To show the upper dorsal spinous processes the arms are brought forward and the neck flexed so that the chin may rest on the upper chest, in which position the elevation of the processes enables their maximum separation from the spine and rib shadows to be demonstrated (351a).

Exposure technique should be adjusted to produce the *minimum* contrast between the roots and the tips of the processes.

Spine: Cervico-dorsal Region



352



353

LATERAL OBLIQUE

This position may be applied when the patient is able to stand or sit and is in a fit condition to be adjusted to the correct posture.

The patient should be placed with the lateral aspect of the trunk toward the film support, with the arm of that side folded over the head and the trunk slightly bent from the waist away from the film support. This allows the film to be adjacent to the axilla and upper arm, and permits of the direction of the beam between the vertically separated shoulders which are at different levels.

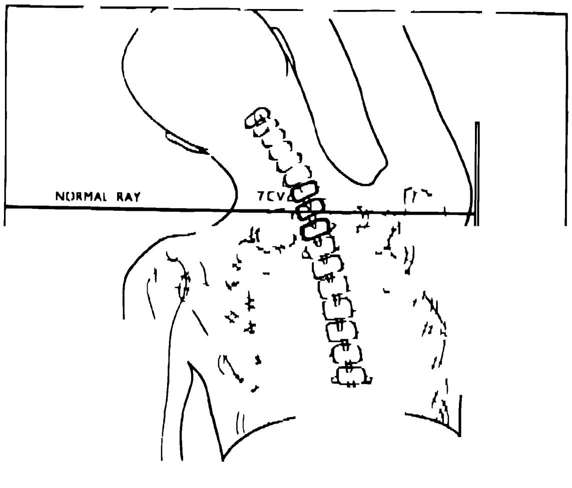
CENTRE above the shoulder remote from the film, toward the axilla adjacent to the film.

(352, 353, 354)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	200	120	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in

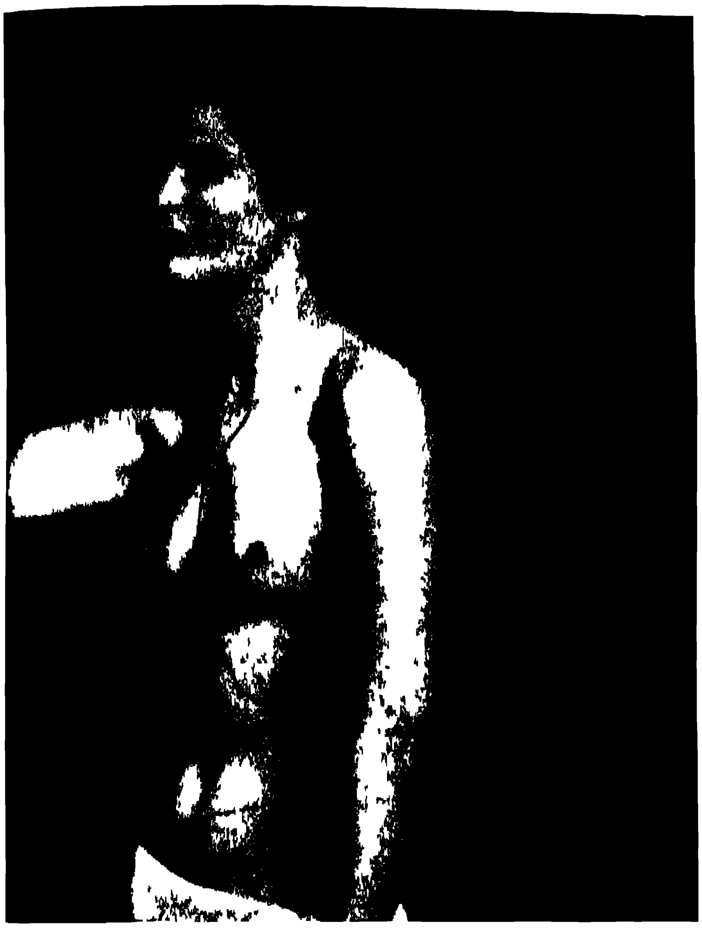
The cervico-dorsal region is well shown without undue distortion, but the adjacent cervical region is grossly over-exposed, and may be overshadowed by the humerus



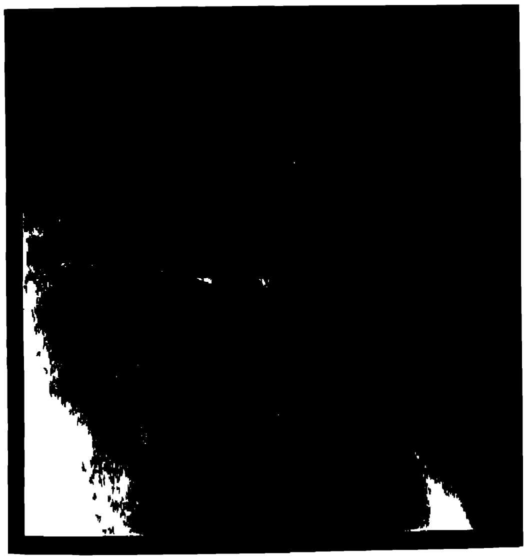
354

The photograph (352) shows the posture of the patient from the anterior aspect, and the diagram (354) the relationship between film, spine, and X-ray beam.

Spine: Cervico-dorsal Region



355



356

ANTERIOR OBLIQUE

From the lateral position the patient is turned slightly away from the film, with the arm nearest to the film raised and in contact with a suitable support to assist immobilisation.

The rotation of the trunk is just sufficient to separate the two shoulders from the right-angle aspect to the film, but, with correct centring, this has little effect on the position as giving a lateral view of the vertebræ.

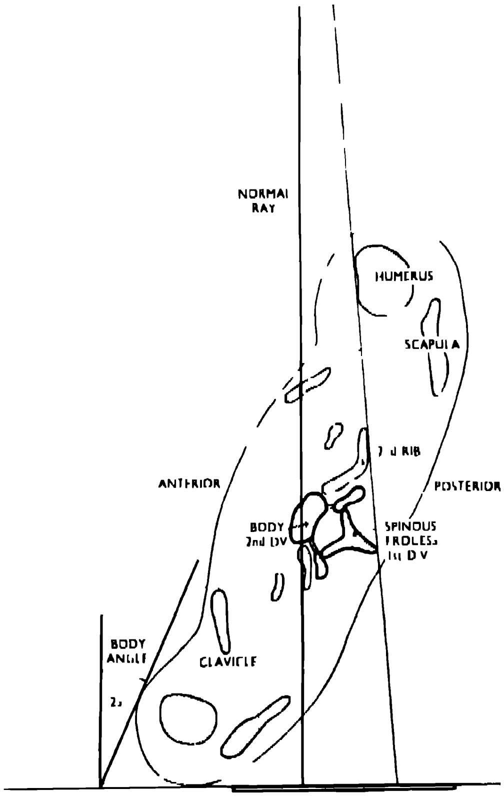
CENTRE to the level of the sternal notch, below the mid-point of the clavicle remote from the film.

It is important that the head should be maintained in the same direction as the trunk.

(355, 356, 357)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	234	142	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.



357

The cross-sectional diagram (357) shows the small degree of rotation of the trunk required to separate the right and left shoulders. A similar view from the posterior aspect of the trunk does not allow of such a satisfactory projection.

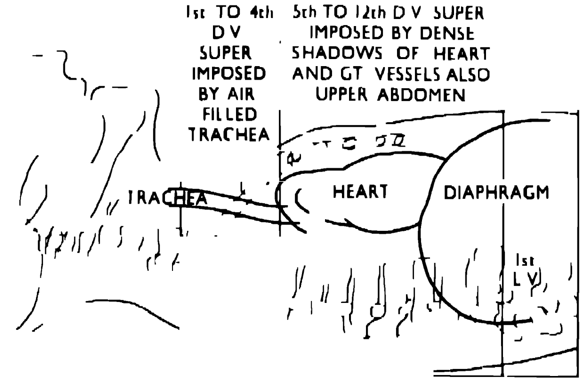
Spine

Dorsal

For the remainder of the spine the Potter-Bucky diaphragm and intensifying screens are always used unless the work is being carried out with a low-power unit, as in ward work: when the Potter-Bucky diaphragm is omitted, however, it may be replaced by the stationary grid.

The technique in both the horizontal and the erect positions is described and illustrated.

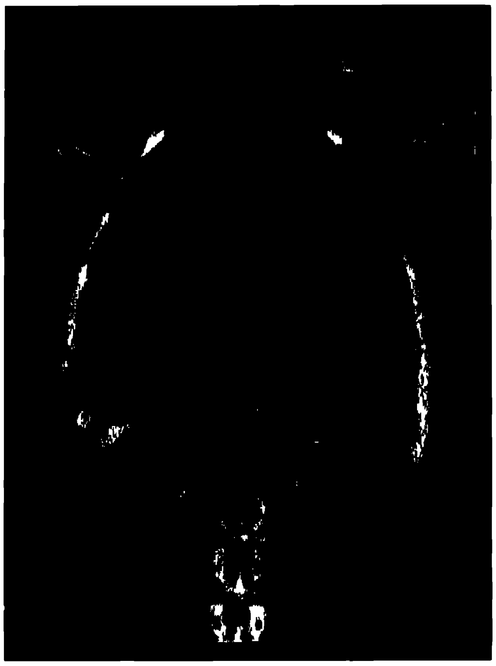
Radiographic densities in the dorsal region vary considerably. From the antero-posterior aspect the radio-transparency of the upper four vertebræ is aided by the superimposition of the air-filled trachea, whereas the lower dorsal region is overshadowed by the heart and aorta and the dome of the diaphragm (358).



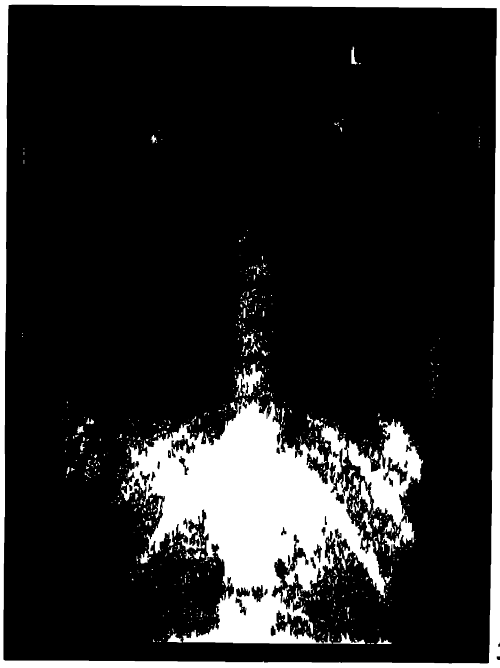
358

These dense shadows over the lower two-thirds of the dorsal spine, combined with the increased thickness of the trunk, necessitate adjustments in the exposure technique to suit the two regions. Radiographs (359, 360) illustrate this point: (359) shows the lower nine vertebræ satisfactorily, with the upper three grossly over-exposed, and (360) shows the upper spine correctly exposed and the lower two-thirds grossly under-exposed. An increased kilo-voltage tends to reduce this great contrast in regional density, as shown in (361).

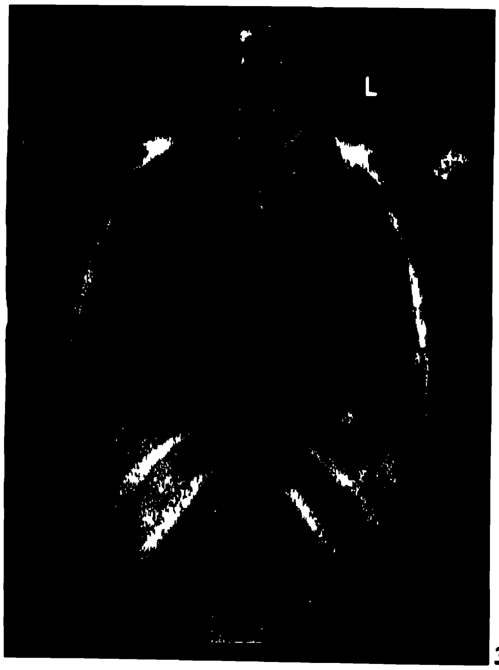
From the lateral aspect the lower eight dorsal vertebræ (excluding the twelfth) are shown through the air-filled lungs, and the bones are clearly demonstrated, but the upper three dorsal vertebræ are obscured by the dense shoulder structures, so that the same technique is not effective in both regions. Although a general technique is quoted, it is usually necessary to make a special examination of the upper three dorsal vertebræ as described under cervico-dorsal technique, thus allowing the position and exposure factors to be varied to suit each region from both aspects.



359

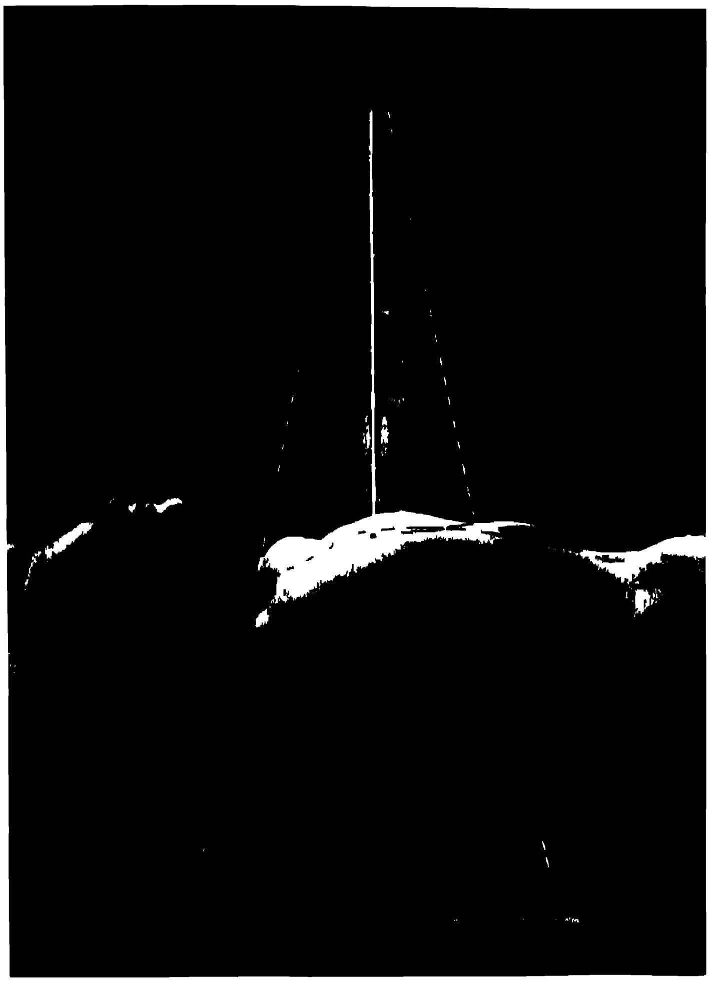


360



361

Spine: Dorsal



362

ANTERO-POSTERIOR

The patient is recumbent, with the spine toward the film.

CENTRE mid-way between the cricoid cartilage and the xiphoid process of the sternum. This will be approximately one inch below the sternal angle.

(362, 361)

The most satisfactory separation of the spinal bodies is obtained when the X-ray beam is directed at right-angles to the arc of the curve formed by the vertebræ. This varies in the individual, and is more easily adjusted with the patient in the erect position. The anode-film distance should approximate the radius of the curve, which will not exceed from 30 inches to 36 inches.

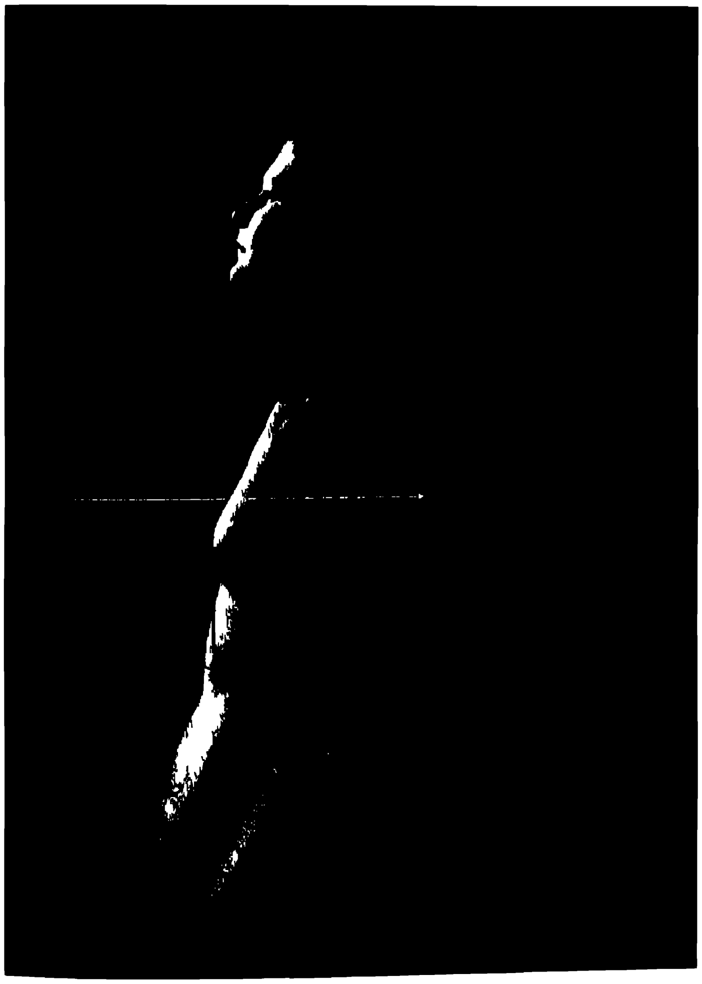
(363)

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	30	18	30″	Ilford	Tungstate	
*70	77	47	36″	Ilford	Tungstate	Stationary
65	200	120	48″	Ilford	Tungstate	Potter-Bucky

Films, 15 × 12 in., 17 × 14 in. or 17 × 7 in.

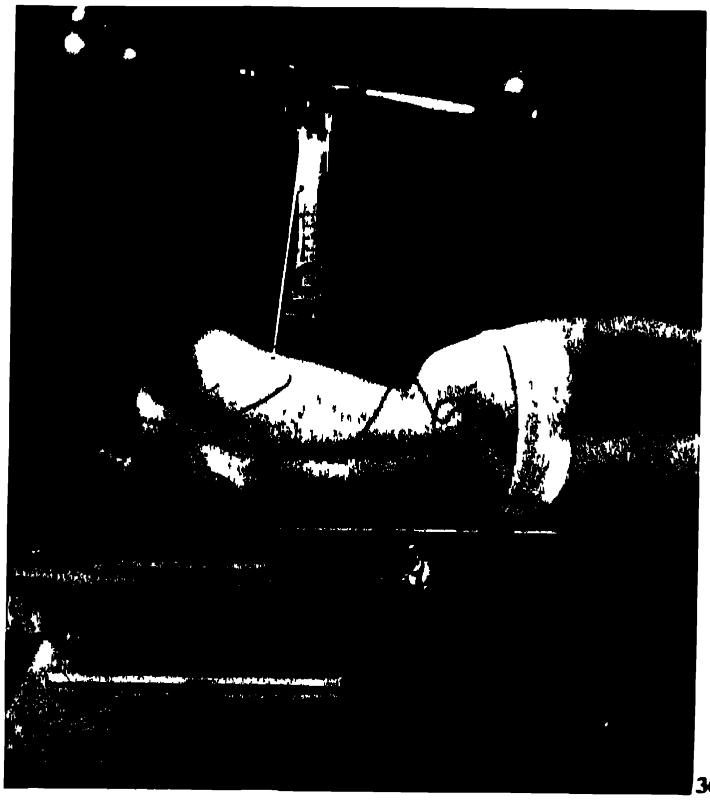
* Ward mobile unit



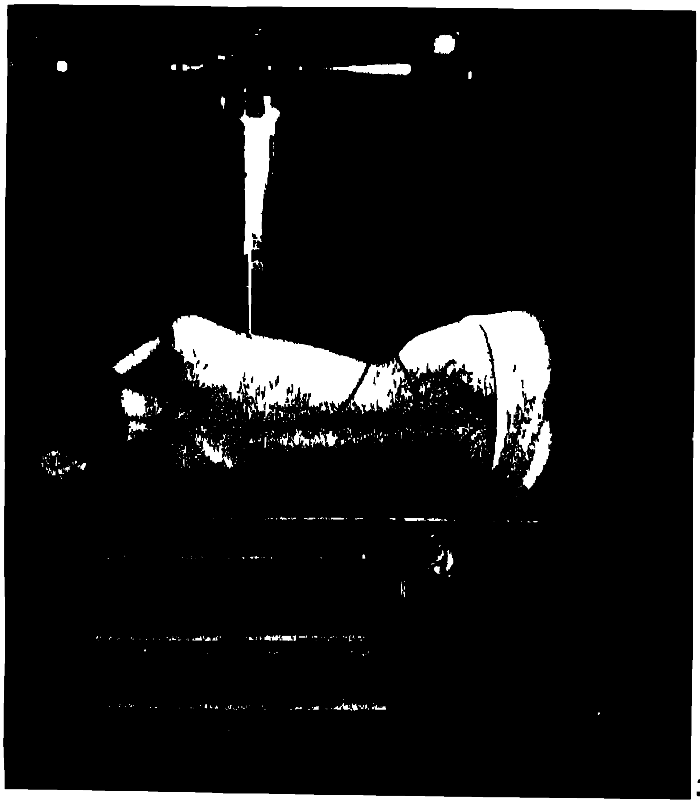
363

NOTE.--In taking general views of the dorsal region from the antero-posterior aspect errors are often made in centring and in placing the film so that the upper three dorsal vertebræ are not included. It should be remembered that the ribs are very oblique and that the sternal angle and second costal cartilage indicate the level of the disc between the fourth and fifth dorsal vertebræ. With the patient supine, the prominent spinous process of the seventh cervical vertebra should be located by touch, and the level traced to the anterior aspect. This will safeguard from error in taking a general view when it is necessary to include the twelve dorsal vertebræ on the same film. Reference should be made to the illustrations on pages 112 and 113.

364



365



366

Spine: Dorsal

LATERAL

The patient is placed in the true lateral position, with hips and knees flexed and the raised limb supported at hip level (364). This view shows the position from above.

The head is comfortably adjusted with pillows so that the cervical spine remains horizontal.

Both arms may be placed well up over the head (364, 367), or the upper arm may be placed at right-angles to the trunk so that the hand may grip the side of the table, with the elbow supported (365). This allows the patient to steady the trunk during the exposure, and the dense shoulder structures are so divided as to show the upper dorsal region.

Each subject should be studied as to the variation in the obliquity of the general axis of the spine in relation to the film. Sagging of the vertebral column toward the waistline may be compensated for by angling the tube toward the head so that the central ray bisects the long axis of the spine at right-angles (365).

A more satisfactory method is to place a non-opaque pad under the lower dorsi-lumbar region so that the lower level of the spine is raised, bringing the long axis of the dorsal region parallel to the film. The tube is then maintained in the normal position so that the axial ray passes at right-angles to spine and film (366).

Whenever it is possible to adjust the relative positions of patient and film that course should be adopted in preference to angling the tube.

CENTRE through the axilla, at the level of the sixth dorsal vertebra, and at right-angles to the long axis of the spine.

(365, 366, 368)

EXPOSURE FACTORS

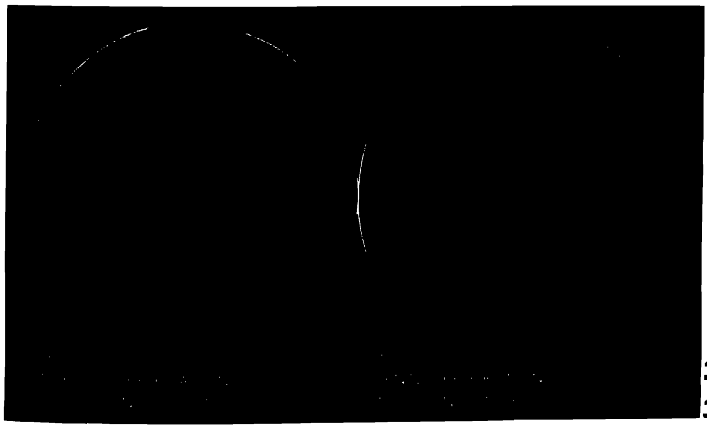
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*70	58	35	30″	Ilford	Tungstate	—
*75	160	97	36″	Ilford	Tungstate	Stationary
80	200	120	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 15 × 12 in., 17 × 14 in. or 17 × 7 in.

* Ward mobile unit.

367

368



368a
368b

LATERAL *(continued)*

NOTE—Miscalculation of exposure may occur in this region in view of the fact that laterally there is greater depth than from the antero-posterior aspect. The lower two-thirds of the dorsal spine is clearly visible through the air-filled lungs, and as the whole of this region is fairly translucent to X rays, the penetration or time may not need to be greatly varied as compared with the antero-posterior view, an increase of five kilovolts usually being sufficient to give the correct film density.

ERECT

The patient stands in the lateral position, and is adjusted to bring the long axis of the spine parallel to the film. The arms may be folded forward over the head, or the outer arm may be placed well forward at shoulder level with the hand in contact with a firm support. The patient may be seated, but the erect posture will then be lost.

CENTRE below the inferior angle of the scapula, at the level of the sixth to seventh dorsal vertebræ.

(367, 368)

NOTE—Lateral chest exposure technique without the Potter-Bucky diaphragm may be preferred.

GENERAL NOTE — In all lateral dorsal technique an increase in the anode-film distance brings the ribs nearest to the tube into focus, and these additional shadows confuse the outlines of the vertebral bodies. To avoid this the patient is allowed to breathe lightly during the exposure, the rib and lung shadows being thus diffused.

These points are illustrated by two radiographs **(368a, b)** of the same patient, (a) exposed for 4/5 second at 100 milliamperes during *arrested respiration*, and (b) for 10 seconds at 10 milliamperes during *gentle respiration*, both taken without the Potter-Bucky diaphragm at an anode-film distance of 48 inches.

INTERVERTEBRAL DISCS

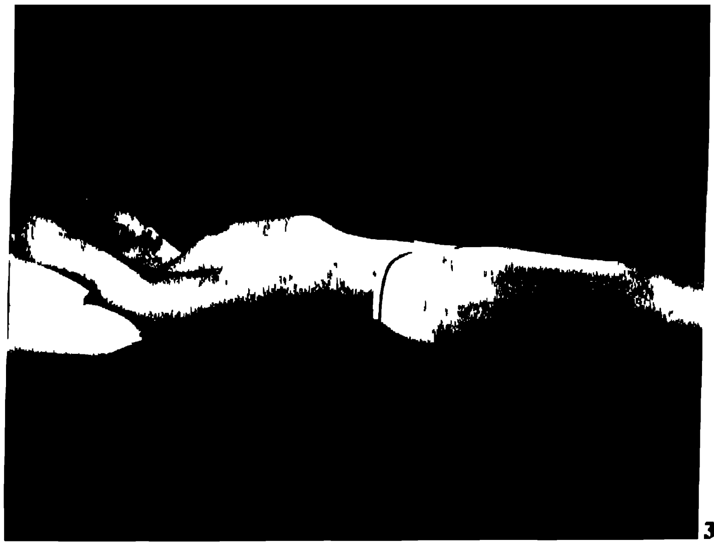
Exacting technique required to demonstrate the vertebral bodies embraces also demonstration of abnormality of the intervertebral discs, which are not usually radio-opaque. Such abnormalities may be disclosed following injection of iodised oil into the subarachnoid space, as described under "Myelography," Section 30, to which reference should be made.

SECTION 7

Spine

SPINE

Lumbar



369

370

371

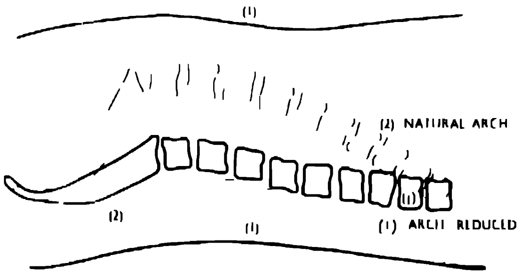
In investigating the remainder of the spine, especially the sacrum and coccyx, it is essential that the bowel of the subject should be free from accumulations of gas and fæcal material.

Unless due consideration is given to the correct positioning of the trunk, the spinal bodies will be projected obliquely from both antero-posterior and lateral aspects to overshadow the intervertebral articular spaces.

As the lumbar spine is convex toward the anterior aspect of the trunk, there being in some subjects a space of from two to three inches between the apex of the curve and the couch, it is necessary, when the patient's condition permits, to reduce this convexity before taking radiographs from this aspect.

In the horizontal position two methods may be adopted to obtain this adjustment of the spine. In illustration **(369)** the patient is supine in the natural position, showing a well marked lumbar arch. In illustration **(370)** the arch has been reduced by flexing the hip and knee joints, thereby causing the spine to straighten; and in **(371)** the alternative method has been used, the shoulders having been raised and a small sandbag placed under the knees, thus bringing the back into contact with the couch.

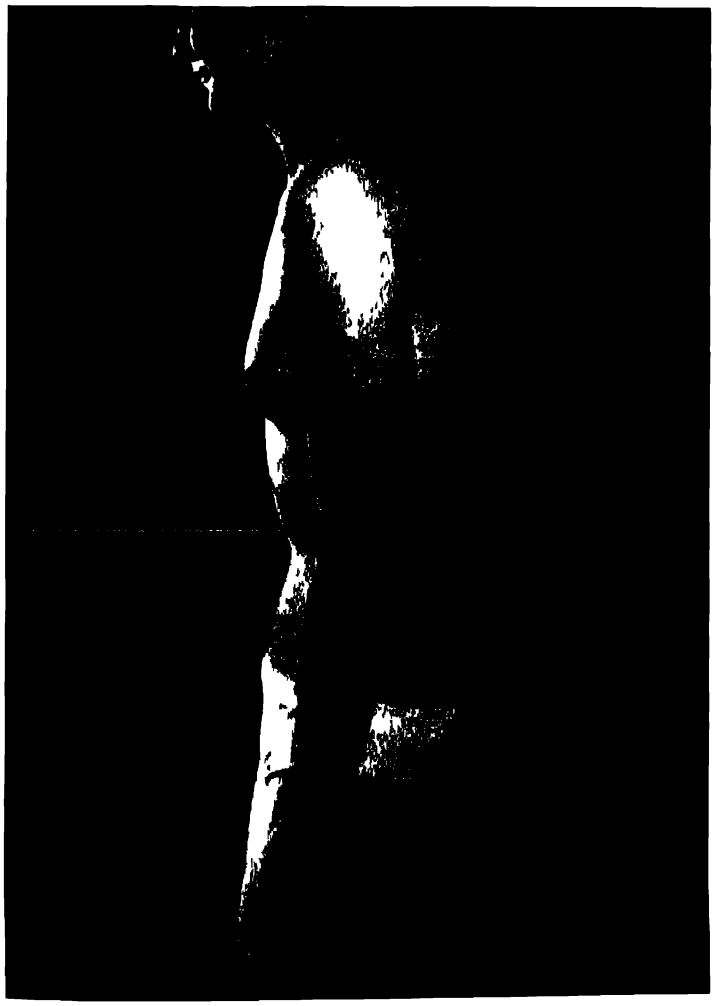
In each instance, and under favourable conditions, the patient is encouraged to reduce the lumbar arch by firm pressure of the operator's hand over the abdomen.



372

The diagram **(372)** shows the varying relationship between spinal bodies and film according to the position of the trunk, and is composed of tracings from two pairs of radiographs taken of the same subject to show soft tissue

373



374

and bone structures, the exposures having been made under the conditions described on page 117 (1) with the back straight (370) and (371) to reduce the lumbar arch, and (2) in relaxation (369), to show the maximum lumbar curve.

The patient standing naturally is shown in (373), with the tube angled to bisect at right angles the general line of the spine. The lumbar arch can be reduced by projecting the shoulders forward, as in (374).

The fifth lumbar vertebra is not always clearly demonstrated in the general antero-posterior view, its appearance depending on the angle at the lumbo-sacral articulation. Illustration (376) on page 134, where the fifth lumbar vertebra is clearly shown because the articulation is almost horizontal, should be compared with (377), where it is foreshortened and the lumbo-sacral articulation obscured owing to the well marked angle. It is therefore frequently necessary to take a special view of the fifth lumbar vertebra, as described under lumbo-sacral articulation, page 140.

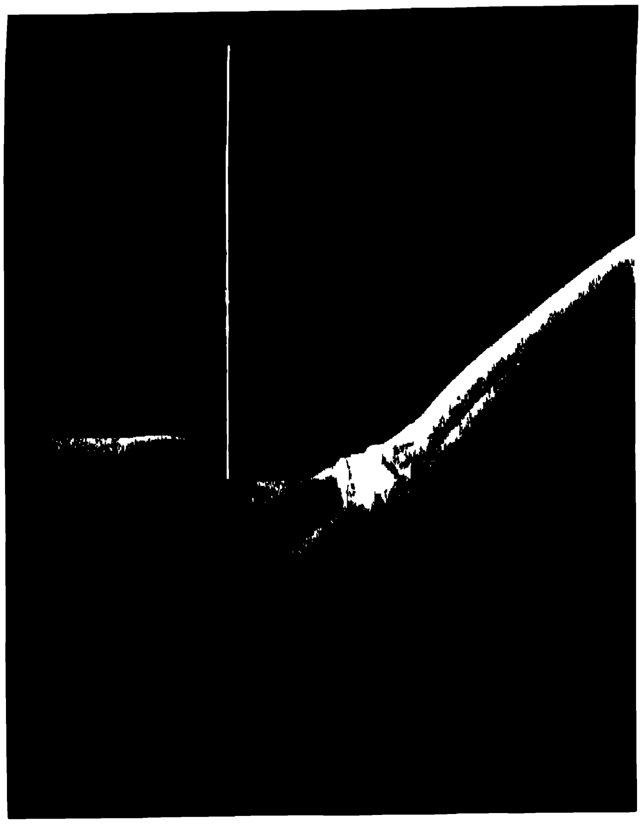
Included in each antero-posterior view of the lumbar spine are the psoas major muscles, which are shown from their origin on the five lumbar transverse processes to the iliac crest (376), where the broad shadows of the muscles, roughly half-way to their insertion into the lesser trochanters of the femora, are obscured by the bones of the pelvis (See diagram (433), page 154).

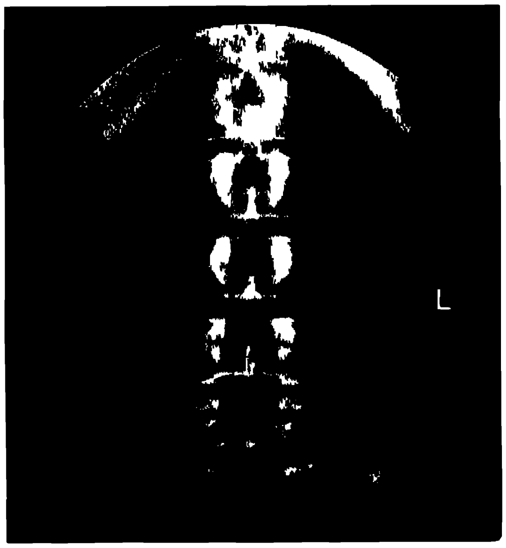
The exposure factors in this section refer to an adult male subject having a weight of 150 pounds and a height of 5 feet 9 inches.

For smaller or larger subjects the kilovoltage may be varied by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent.

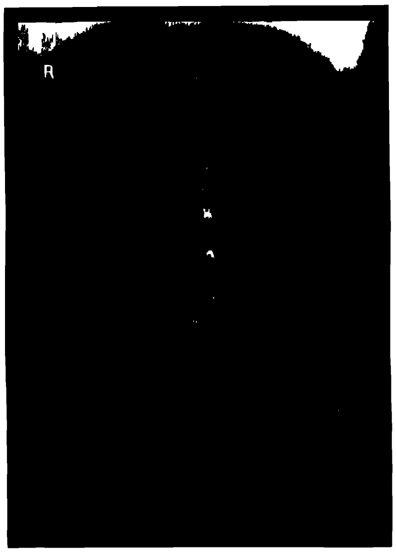
The technique includes antero-posterior, postero-anterior, lateral and oblique views.

Spine: Lumbar


375



376



377

ANTERO-POSTERIOR

If the usual method of straightening the spine is applied, radiographs should be taken from the antero-posterior aspect, and, when the apparatus permits, the film should be exposed from an anode-film distance of 48 inches to avoid enlargement distortion. This applies in both horizontal and erect technique.

For the horizontal position, shown in (375), the knees are raised to reduce the lumbar arch, a sandbag being placed across the feet to maintain the limbs in position. The spine is carefully adjusted to the middle of the couch.

CENTRE in the mid-line, between the lower costal margins, at the level of the third lumbar vertebra.

(375, 376, 377)

NOTE—The tendency is to centre at too low a level and thus to include a considerable portion of the sacrum while omitting the upper two lumbar vertebræ. [See antero-posterior comparative levels on pages 112 and 113.]

It is *essential* to include the dorsi-lumbar and the lumbo-sacral articulations when a 12 inch by 10 inch film is used (376), and the lower dorsal and sacral regions may also be included on a 15 inch by 12 inch film (377).

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	38	23	30"	Ilford	Tungstate	—
65	102	62	36"	Ilford	Tungstate	Stationary
65	264	160	48"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 15 × 12 in.

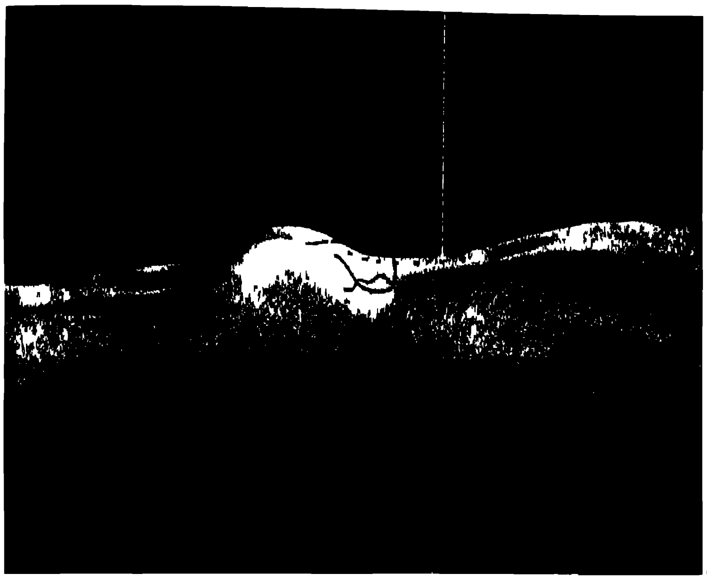
* Ward mobile unit

POSTERO-ANTERIOR

The present tendency to radiograph under conditions normal to the patient suggests centring to the highest point of the curve from the postero-anterior aspect, particularly when the spinal convexity is very marked.

In a large number of thin subjects the distance between the spine and film from this aspect is less than, or at least equal to, that in the antero-posterior position, and if the natural curve is preferred radiographs should be taken with the patient facing the film.

Spine: Lumbar


378

POSTERO-ANTERIOR (*continued*)

HORIZONTAL

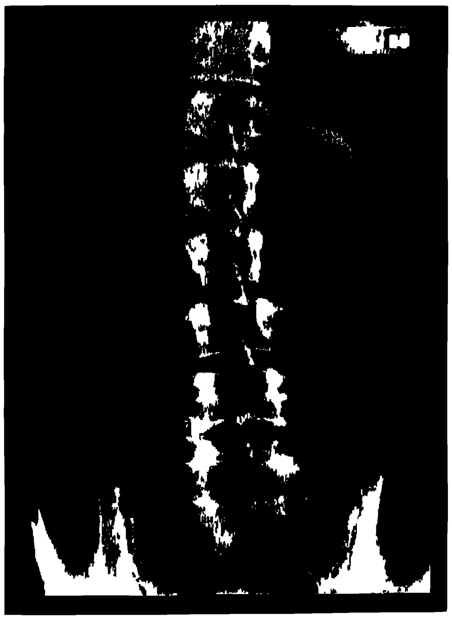
With the patient in the prone position, a sandbag is placed under the ankles for comfort, and the head allowed to turn to one side (378).

ERECT

With the patient facing the film, the shoulders are allowed to press with equal firmness against the film support, with the head turned to one side and the feet separated to give even balance to the trunk.

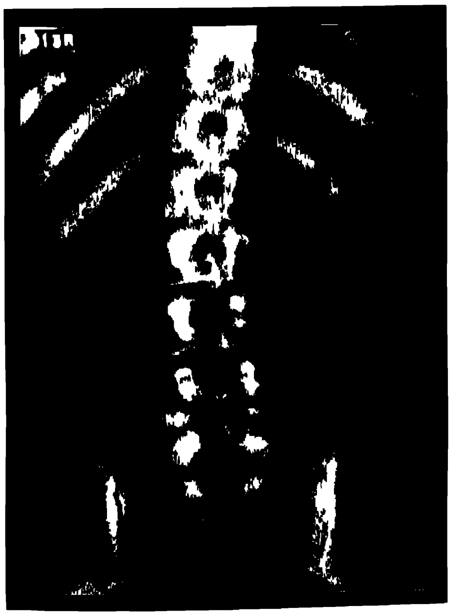
CENTRE for both positions in the mid-line over the third lumbar vertebra, at the level of the lower costal margin.

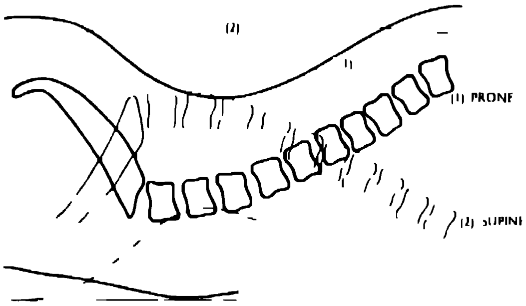
(378, 379)


Prone
379

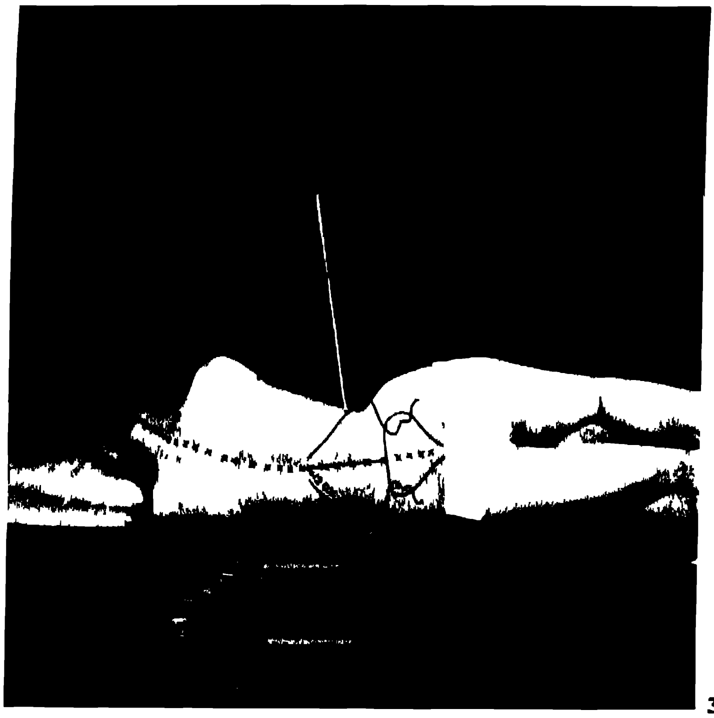
Radiographs taken from both aspects of the trunk will serve to dispel the illusion that the lower spine can only be radiographed from the antero-posterior aspect. It is important that this should be borne in mind when the condition of the patient does not allow rotation on to the back.

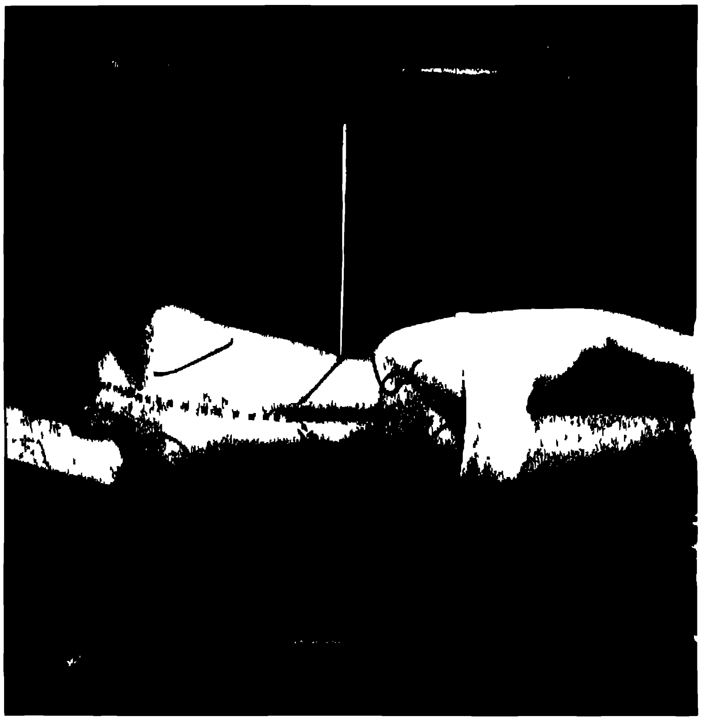
Radiographs were taken of the same subject, (379) in the prone position, and (380) in the supine position, the natural posture being maintained. The exposures were made under similar conditions, using an anode-film distance of 30 inches. The films show how little difference there is in definition from the two aspects, the most marked variation occurring toward the lumbo-sacral region, where there is increased enlargement distortion in the postero-anterior view.


Supine
380



The diagram (381) shows, by longitudinal section, the difference in the tube-spine-film relationship from (1) postero-anterior, and (2) antero-posterior aspects. This was prepared from tracings taken from the original lateral radiographs exposed in pairs, to show both soft tissue and bone structures, by the method described on page 117.


382


383


384

Spine: Lumbar

LATERAL—HORIZONTAL

When circumstances permit, the patient is moved into the lateral position, with the knees and hips flexed and the raised leg supported at hip level (382). The under-arm is placed under the head to ensure that the elbow is away from the spine, and the upper arm is allowed to grasp the side of the couch to steady the trunk in position, or the upper arm may be allowed to extend upward over the head, thus assisting in straightening the spine. A pad of cotton wool between the hip joint and couch adds to the patient's comfort.

The long axis of the lumbar spine tends to be oblique in direction from the first to the fifth lumbar level, as the body sags at the waist toward the film (382). This is especially marked in women patients, where the pelvis is usually broad: in male patients, owing to the pelvis being narrow, the spine may be quite horizontal.

To adjust the long axis of the spine parallel to the film a thick wool pad is placed under the dorsi-lumbar region (383). Alternatively, the tube may be angled toward the feet, so that the central ray bisects the long axis of the spine at right angles (382). Unless this adjustment is made there will be overlapping of the spinal bodies in the radiographs, with consequent obscuring of the inter-vertebral spaces occupied by the fibrocartilages, as shown in the lower vertebræ of (386) as compared with (385). When apparatus conditions are suitable, the anode-film distance should be increased to 48 inches to reduce the enlargement distortion due to the distance between the spine and the film.

CENTRE to a point four inches in front of the third lumbar spinous process: this is the level of the lower costal margin. (382, 383, 384)

EXPOSURE FACTORS

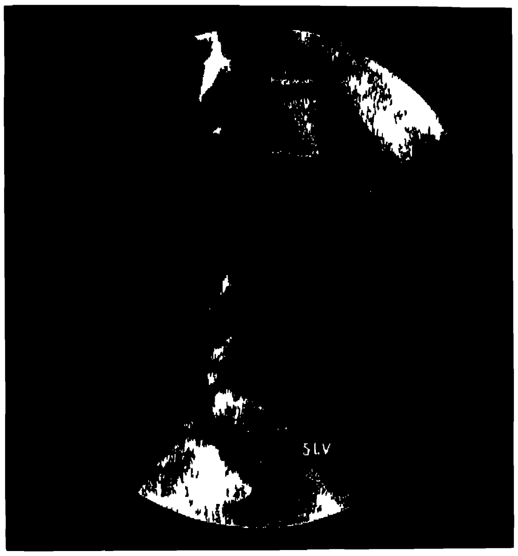
kVp.	mA. Secs. Ilford Developers X-ray	Blue Label	Distance	Film	Screens Ilford	Grid
*80	66	40	30"	Ilford	Tungstate	—
80	460	280	48"	Ilford	Tungstate	Potter-Bucky
80	300	180	48"	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 12 × 10 in. or 15 × 12 in.
* Ward mobile unit.

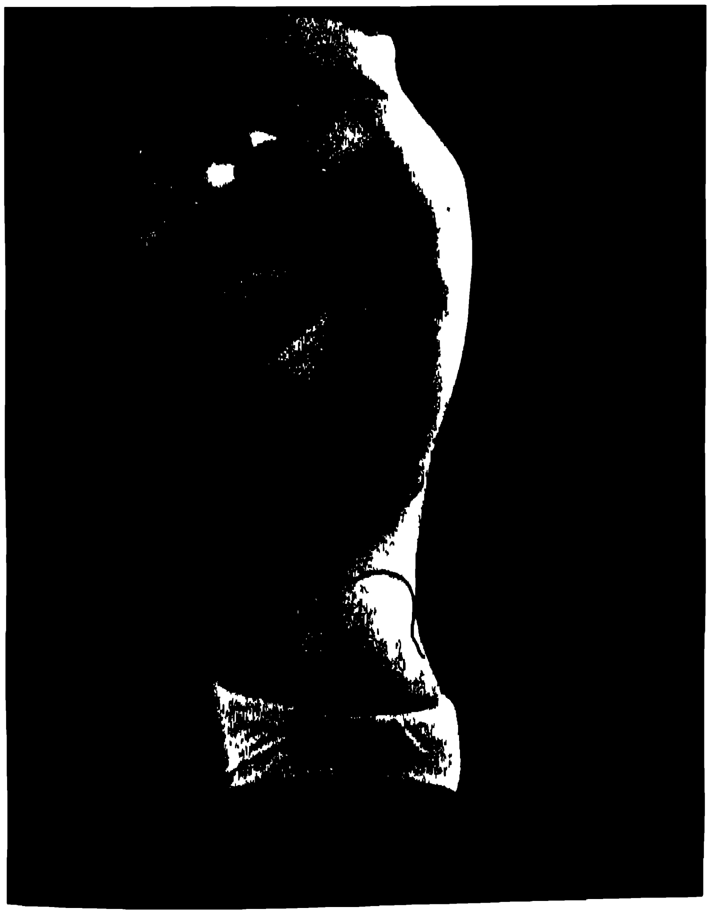
NOTE—Each film should include the dorsi-lumbar and the lumbo-sacral articulation when taken on a 12 inch by 10 inch film (386), and the lower dorsal spine and upper sacrum when a 15 inch by 12 inch film is used, as in (384).

Spine: Lumbar

385



386



387

LATERAL *(continued)*

From the lateral aspect the fifth lumbar vertebra is over-shadowed by the iliac crests, so that the radiographic density in this region is greatly increased. The upper level of the iliac crests in relation to the fifth lumbar vertebra will be seen by reference to page 104, dealing with the pelvic girdle. In very broad subjects there is very considerable variation in film density between the first and the fifth lumbar vertebræ, and the lateral pelvis exposure factors are therefore more suitable.

This point is demonstrated in (385) and (386), the exposure factors having been varied to show the fifth lumbar vertebra in (386) and the upper four lumbar vertebræ, the fifth being excluded owing to under-penetration, in (385). These radiographs also show the differences in the radiographic appearance when the long axis of the spine is parallel to the film, as in (385), and when the spine sags toward the waist-line without correcting the tube angle, as in (386), which has been discussed on the previous page.

When investigating disease of the spinous *processes* it is necessary to reduce the exposure time by half, since in the general views of the spine these processes tend to be grossly over-exposed, although an increased anode-film distance and high kilovoltage, as in (384), tend to show all structures equally well.

LATERAL—ERECT

The patient stands and is adjusted in the lateral position, with the axis of the lumbar spine parallel to the film. The feet are slightly separated to give balance, and the arms folded and allowed to rest on the film support.

Centring point and exposure factors are applied as for horizontal technique (387, 384).

STRETCHER PATIENTS

Seriously injured patients brought to the X-ray department in the prone position, shown in (388), should be radiographed in this position from both lateral and postero-anterior aspects.

Clothing containing metallic objects should be removed from the spine area, and the patient covered with blankets throughout the examination.

388

Spine: Lumbar

STRETCHER PATIENTS (*continued*)

LATERAL

For the lateral position the film is supported in the vertical plane adjacent to the lateral aspect of the trunk, the tube of the ward mobile unit being adjusted to the horizontal position

CENTRE three inches anteriorly from the third lumbar spinous process, at the level of the lower costal margin

(388, 389)

389

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers BlueLabel	Distance	Film	Screens Ilford	Grid
*82	66	40	30	Ilford	Tungstate	—
*82	182	110	30	Ilford	Tungstate	Stationary
*82	120	73	30'	Ilford	Fluorazure	Stationary

Cone to size of film 12 × 10 in or 15 × 12 in
* Ward mobile unit

NOTE—As discussed on page 113, this horizontal centring is not always applicable when the patient is *supine*, as the metal sides of the *curved* topped stretcher trolleys, frequently in use, obscure the spinal bodies In addition, the cassette cannot be placed at a low enough level for the film to receive the projected shadows The need for a specially constructed, but not necessarily elaborate or expensive, X-ray stretcher trolley cannot be too greatly emphasised

390

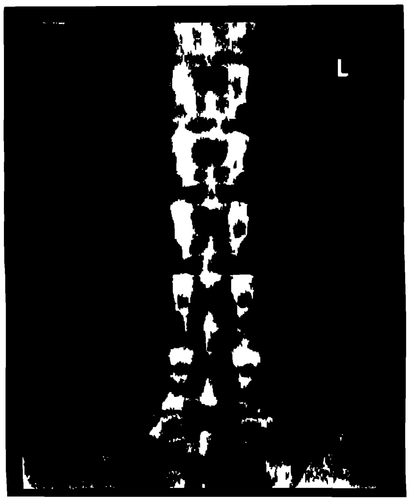
POSTERO-ANTERIOR

For the postero-anterior position great care is necessary in raising the patient to insert the film under the blanket or stretcher cloth, but in using a specially constructed stretcher trolley the film is placed beneath the stretcher top, and movement of the patient is avoided.

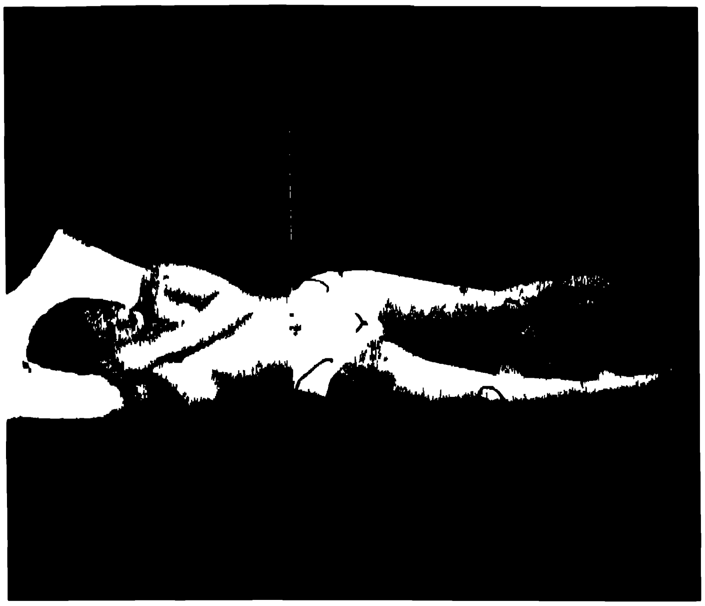
CENTRE in the mid-line over the third lumbar spinous process, at the level of the lower costal margin.

(390, 391)

NOTE—Radiographs **(389)** and **(391)** were taken with a fifteen milliampere ward mobile unit, using a stationary grid.

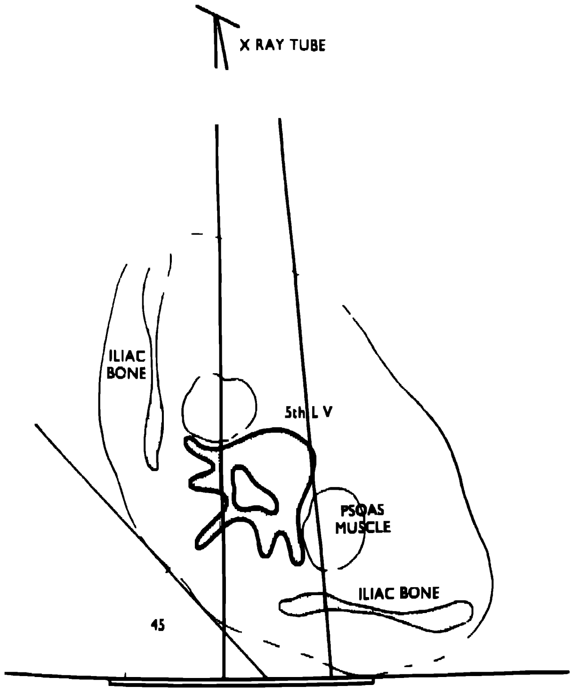


391



392

393



394

Spine: Lumbar

POSTERO-ANTERIOR *(continued)*

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*66	38	23	30"	Ilford	Tungstate	—
*65	104	73	30"	Ilford	Tungstate	Stationary

Cone to size of film, 12 × 10 in or 15 × 12 in

* Ward mobile unit

OBLIQUE

The patient is adjusted to a half-lateral position, at an angle of 45 degrees from the antero-posterior position, with sandbag support under the lower dorsal spine and under the raised limb. Both sides are taken in turn to provide right and left oblique views.

CENTRE in the mid-clavicular line, at the level of the third lumbar vertebra.

(392, 393, 394)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	102	62	36	Ilford	Tungstate	Stationary
70	264	160	48	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 15 × 12 in

These views show the actual articulations between the articular processes of the vertebræ and the vertebral bodies from the oblique aspects. They are particularly useful for very heavy subjects where there is difficulty in showing the fifth lumbar body from the lateral aspect, and, when this is the sole purpose of the exposure, the centring point should be adjusted to the mid-line, at the level of the anterior superior iliac spines [**(404)**, page 143].

The diagram **(394)** shows a cross-section of the trunk at the level of the fifth lumbar vertebra, and illustrates the method of obtaining an oblique projection of the spine.

Spine

Lumbo-Sacral Articulation

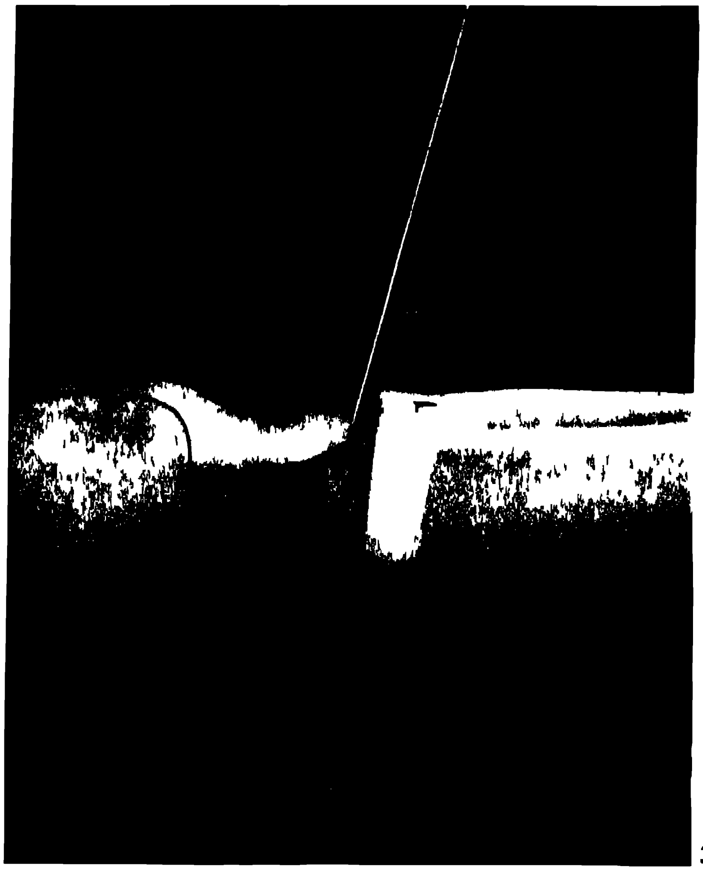
It is frequently necessary to examine the lumbo-sacral articulation as distinct from the lumbar spine or sacrum, and as the joint surfaces deviate from the horizontal and also occupy a position of great regional density, viewed laterally, special technique is required for both antero-posterior and lateral positions.

ANTERO-POSTERIOR

The patient is placed in the supine position and carefully centralised on the X-ray couch, with the film displaced toward the head, to coincide with the oblique projection of the X-ray beam.

CENTRE in the mid-line, at the level of the anterior superior iliac spines, with the tube angled 5 degrees to 15 degrees toward the head. The degree of angulation required will vary according to the type and sex of subject.

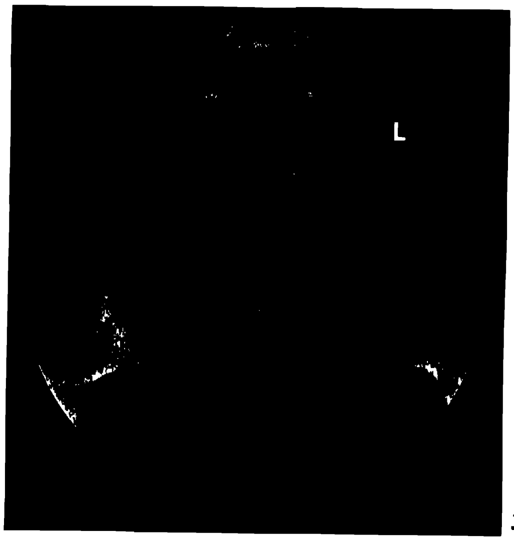
(395, 396)



395

EXPOSURE FACTORS						
kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	165	100	36"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.



396

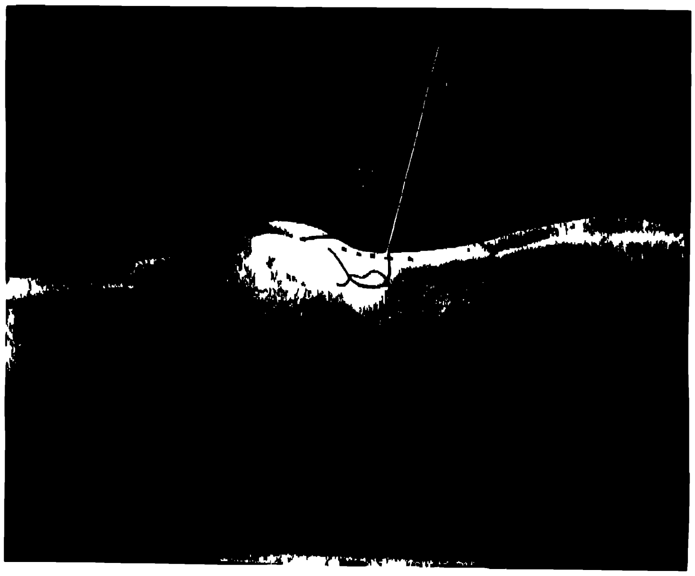
NOTE—Radiographs taken of the lumbar spine usually give a foreshortened view of the fifth lumbar vertebra, and the lumbo-sacral articulation is obscured, but a satisfactory view of the joint is obtained in films of the sacrum.

POSTERO-ANTERIOR

The lumbo-sacral articulation is displaced sufficiently forward in the trunk to allow satisfactory views to be taken with the patient in the prone position. From this aspect it is perhaps easier to estimate the direction of the articular surfaces and thus the extent of the tube angulation required.

CENTRE to the fifth lumbar spinous process, with the tube angled from 5 degrees to 15 degrees toward the feet.

(397, 398, 398a)



397

Spine: Lumbo-Sacral Articulation

POSTERO-ANTERIOR (*continued*)

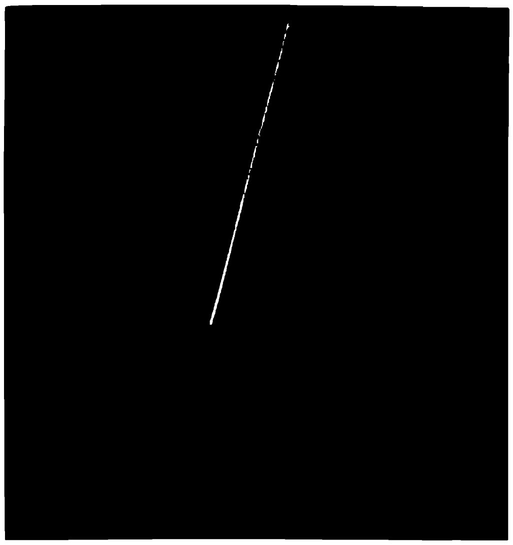
The lateral radiograph (**398**), placed to show the position occupied by the vertebræ in the figure shown in (**397**), indicates the tube angulation required in order to project a clear view of the lumbo-sacral articulation (**398a**).

As will be seen by comparing radiographs (**396**) and (**398a**), antero-posterior and postero-anterior views are both satisfactory. Either of these may be taken equally well in the erect position, except that immobilisation is not so easily maintained.

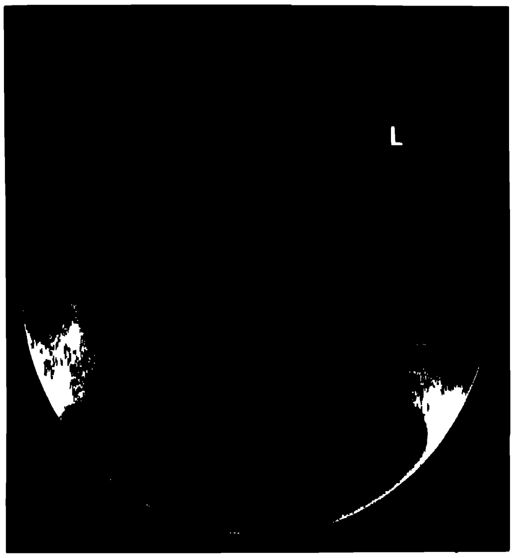
PATHOLOGICAL RADIOGRAPHS

Two views of the lumbo-sacral region disclose the condition known as spondylolisthesis. It will be seen that diagnosis in this type of case depends very largely on the production of a technically satisfactory lateral view (**399a, 400**).

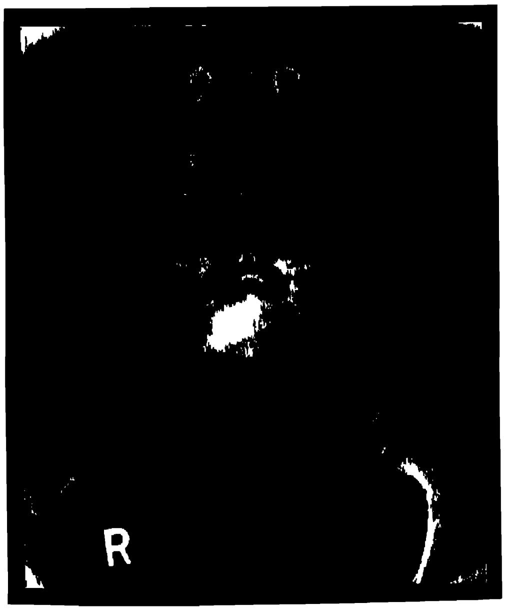
NOTE. Spondylolisthesis is the name given to the condition arising from a forward displacement of one vertebra upon another, and is usually met with in the lumbo-sacral region. The illustration shows displacement of the fifth lumbar vertebra upon the sacrum.



398



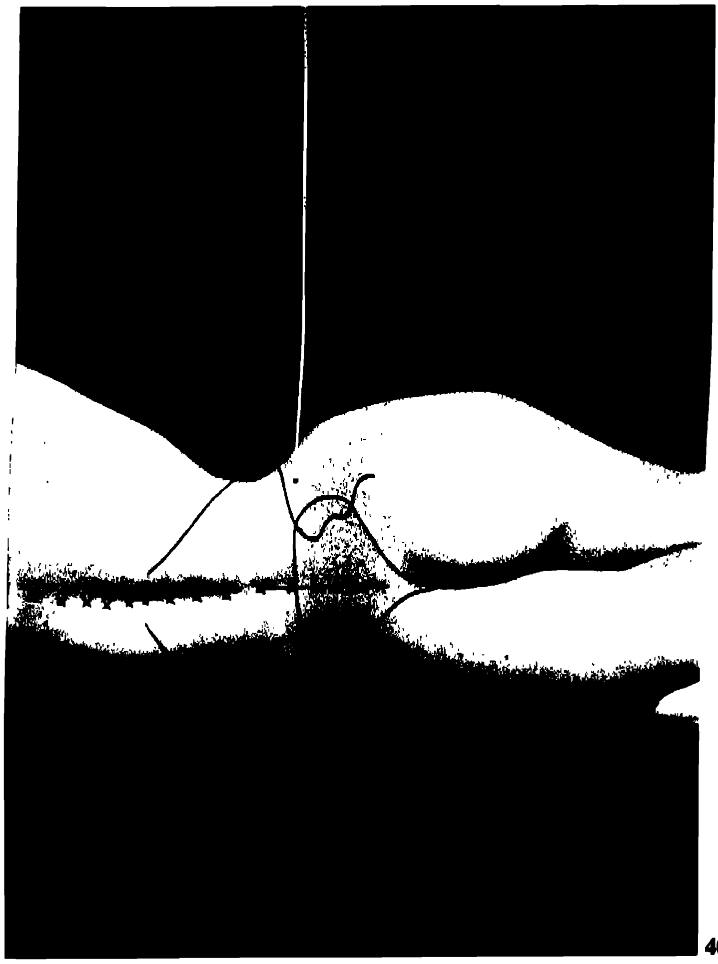
398a



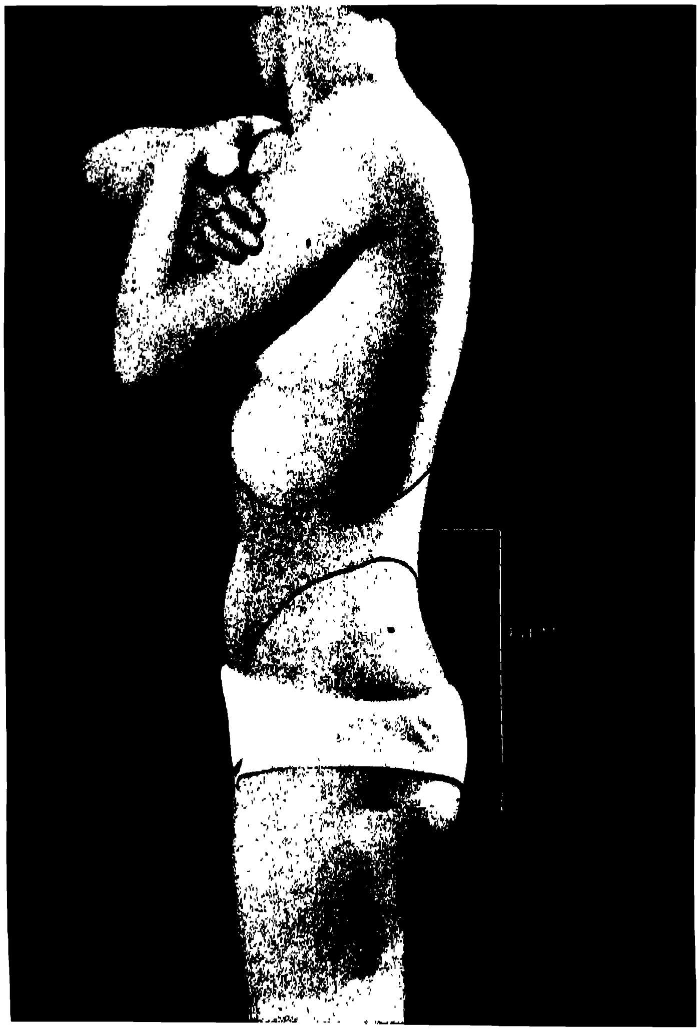
399

399a

Spine: Lumbo-Sacral Articulation



400



401

LATERAL

Films taken laterally, with the patient in both the erect and the horizontal positions, show differences in the alignment of the lumbo-sacral region due to posture. The same differences are shown according to whether the patient is lying with the full length figure extended or relaxed, as shown in diagram (372), page 132.

It is important to adjust the patient to the true lateral position, with the mid-line of the lumbo-sacral region parallel to the film. In the horizontal position a soft wool pad under the mid-lumbar region will have the desired effect, and a smaller pad between the hip and couch will be appreciated by the patient. Flexion of hips and knees, with the raised limb supported on sandbags on the side of the couch, assists immobilisation.

In the erect position the shoulder rests against the film support, the feet being placed apart to give balance (401).

CENTRE three inches forward from and at the level of the fifth lumbar spinous process.

(400, 401, 402)

EXPOSURE FACTORS

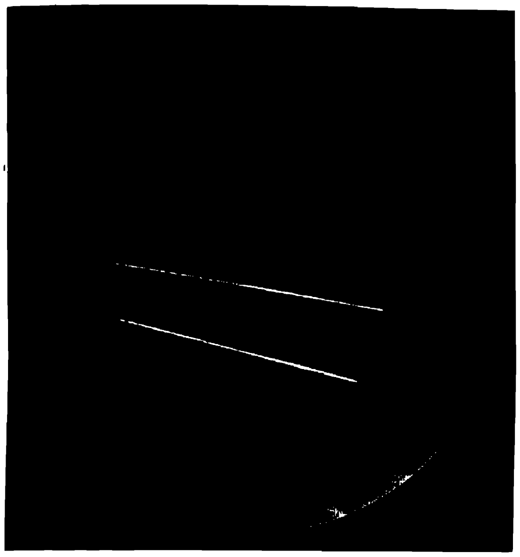
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
86	264	160	36″	Ilford	Tungstate	Potter-Bucky
86	175	106	36″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

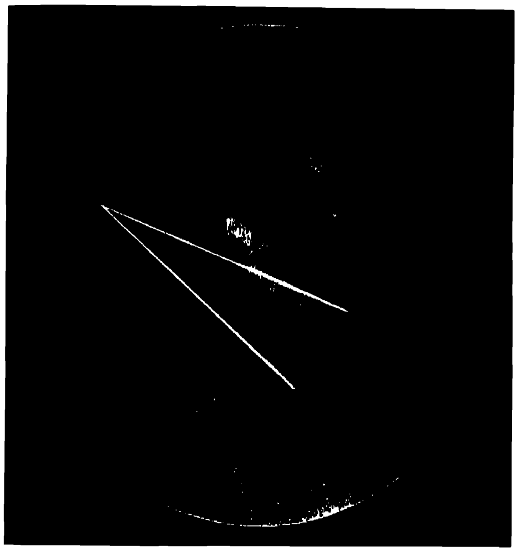
NOTE—The great density of this region prohibits an excessive anode-film distance to compensate for spine-film displacement unless a high-power unit is available, but at 36 inches, using a localising cone and fast screens, satisfactory results are obtained.

The two radiographs (402) and (403) were taken of the same subject, (402) with the spine straightened by flexing the hips and bending the shoulders forward, with the patient in the horizontal position, [see (400), also (364), page 128], and (403) with the spine curved by extending the hips and straightening the shoulders [(298) page 107], this being similar in effect to the erect position (401). These should be compared with special reference to the lumbo-sacral articulation.

Spine: Lumbo-Sacral Articulation



402

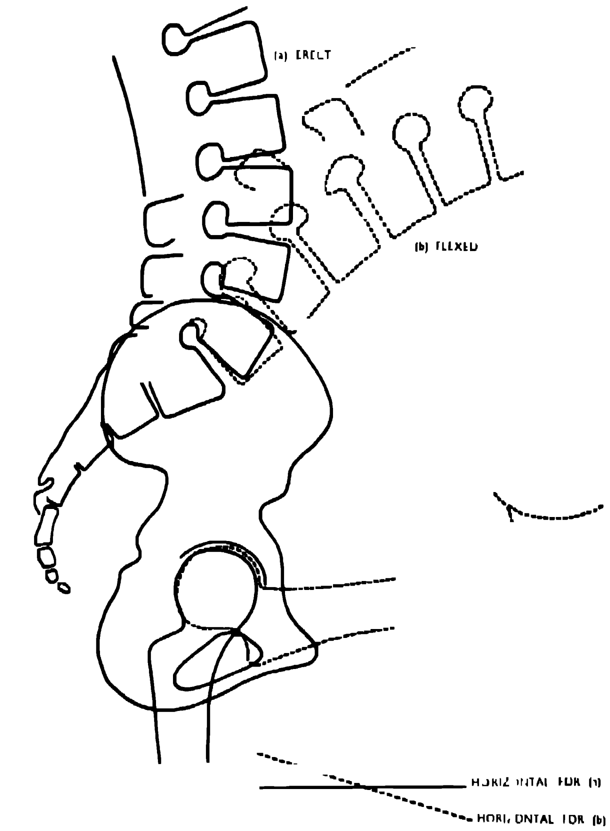


403

404

LATERAL (*continued*)

Tracing diagrams taken from radiographs exposed in two positions, with the patient standing (a) erect, and (b) flexed, are of interest, the pelvis shadows having been placed together to disclose spine-pelvis relationship **(402a)**.



402a

OBLIQUE

This position is taken in exactly the same way as the oblique lumbar spine **(392)**. The patient is rotated 45 degrees from the supine position, and supported and immobilised with cotton wool pads and sandbags.

CENTRE 3 inches forward from the posterior aspect of the trunk, at the level of the anterior superior iliac spines.

(392, 404)

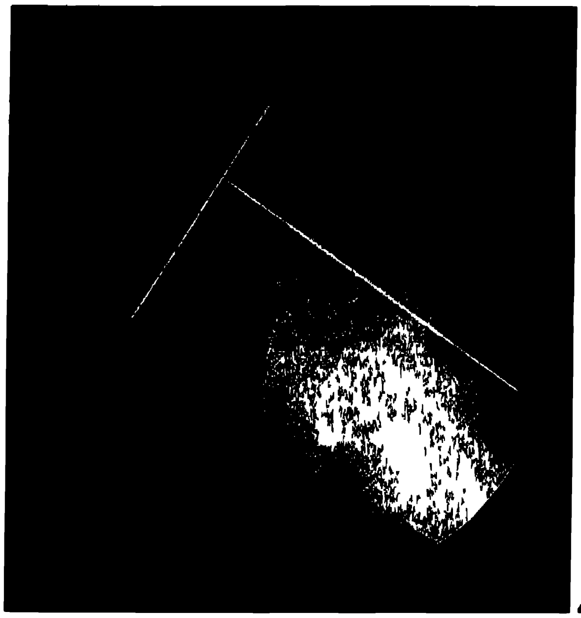
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
76	102	62	36″	Ilford	Tungstate	Stationary
76	264	160	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

NOTE—This method of projection is shown in cross-sectional diagram **(394)** on page 139.

Sacrum



405

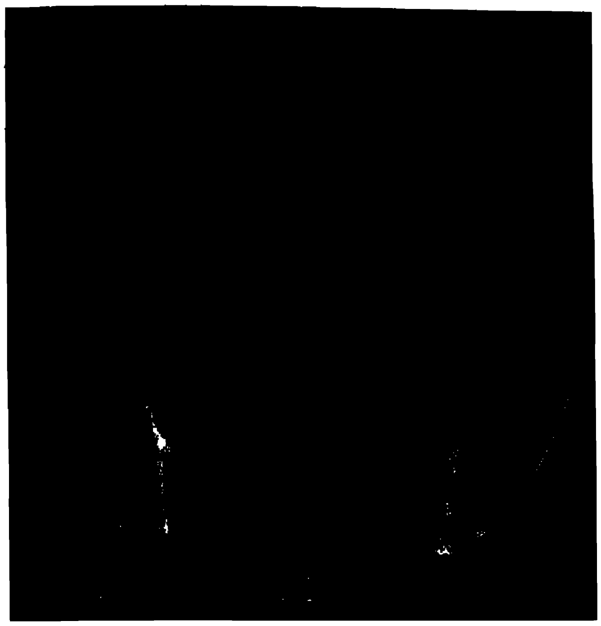
406

The sacrum consists of five vertebræ, fused together to form a triangular wedge, situated between the iliac bones and completing the posterior portion of the pelvic girdle.

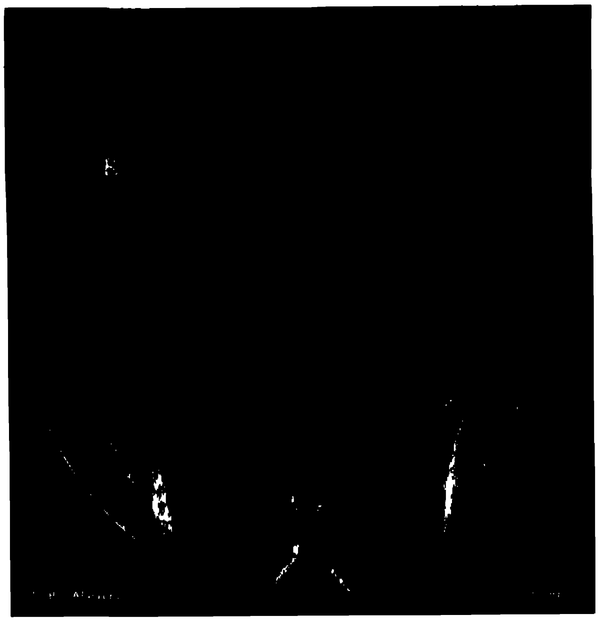
It is oblique in direction, sloping backward and downward, forming an acute angle, sometimes called the promontory, at its articulation with the fifth lumbar vertebra. In this obliquity male and female subjects differ. In the typical male the lumbo-sacral angle is small, with the long axis of the sacrum almost vertical, but in the female subject the lumbo-sacral angle may be considerable, necessitating an adjustment in technique in order to obtain an undistorted antero-posterior view.

The two radiographs taken from the lateral aspect show the possible variation between the male (**405**) and female (**406**) lumbo-sacral angle. The white lines indicate the direction of the X-ray beam from the antero-posterior aspect, and (**406**) shows that in this type of subject the sacrum is always foreshortened in the antero-posterior view unless overshadowed by the pubic bones.

Radiographs (**407**) and (**408**) taken of a male should be compared with (**409**) and (**410**) taken of a female subject. In each of the four films the same centring point was used, but in male (**407**) and female (**409**) the tube was straight, showing a little foreshortening in the male, and gross foreshortening in the female sacrum, owing to the smaller lumbo-sacral angle in the male and the exaggerated angle in the female. In male (**408**) and female (**410**) the tube was angled 10 degrees toward the head, showing over-angling for the male, with the lower sacrum overshadowed by the pubic bones, and still a little foreshortening of the female sacrum, which is rectified in the fifth radiograph (**411**), taken with the tube angled 15 degrees toward the head.



407



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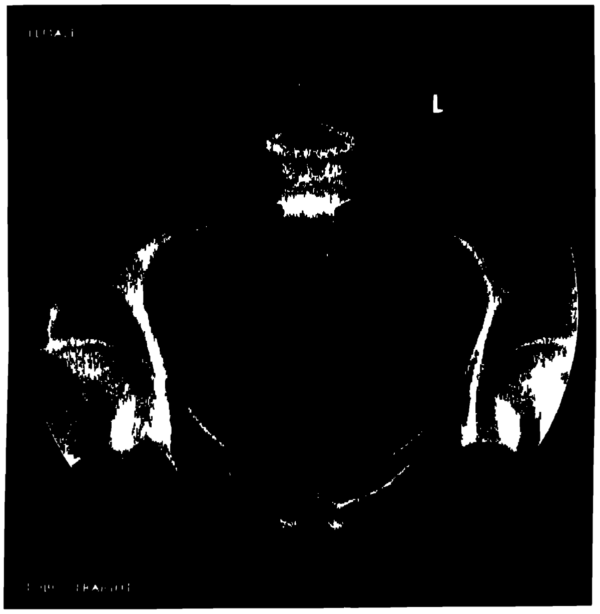

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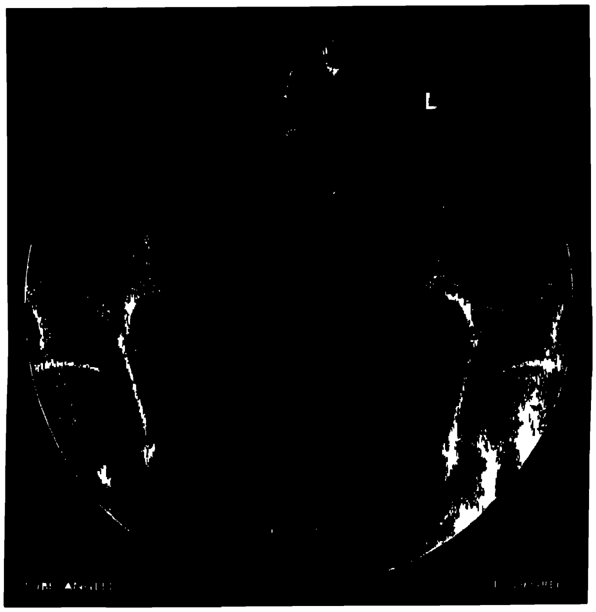

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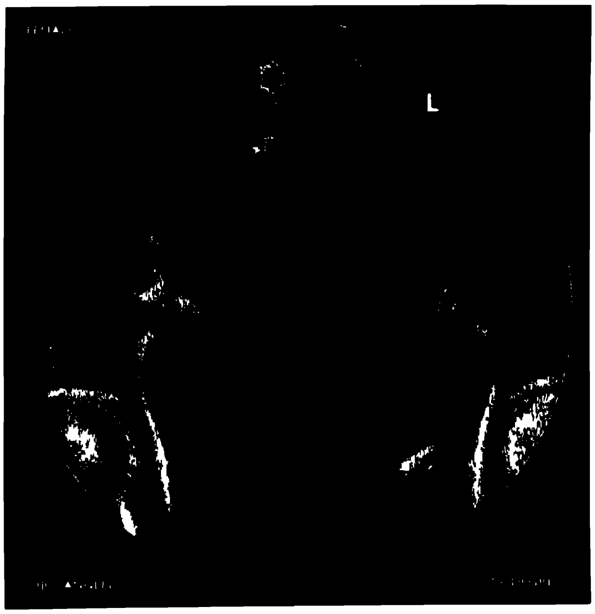

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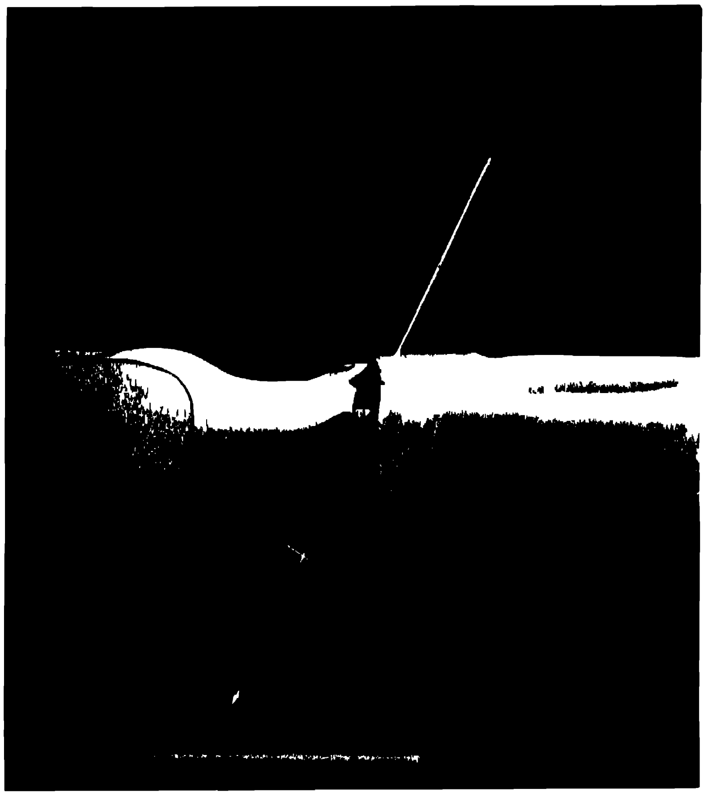


412

413

Spine: Sacrum

ANTERO-POSTERIOR

The patient is supine, with the knees flexed over a small sandbag and the shoulders raised to reduce the lumbar arch.

CENTRE in the mid-line above the symphysis pubis, with the tube angled 10 degrees to 15 degrees toward the head. The degree of angulation will depend entirely upon the angle of the sacrum in relation to the film.

(412, 413)

In each case the central ray is directed as nearly as possible at right angles to the long axis of the sacrum, the position of the film being adjusted to the varying projections depending on the tube angulation. The illustrations on the previous pages show the different tube angles required according to type of subject and sex, and also some of the possible differences between the male and female sacrum: the same centring point has been used, rendering the view with the tube straight directly comparable with that with the tube angled in each case.

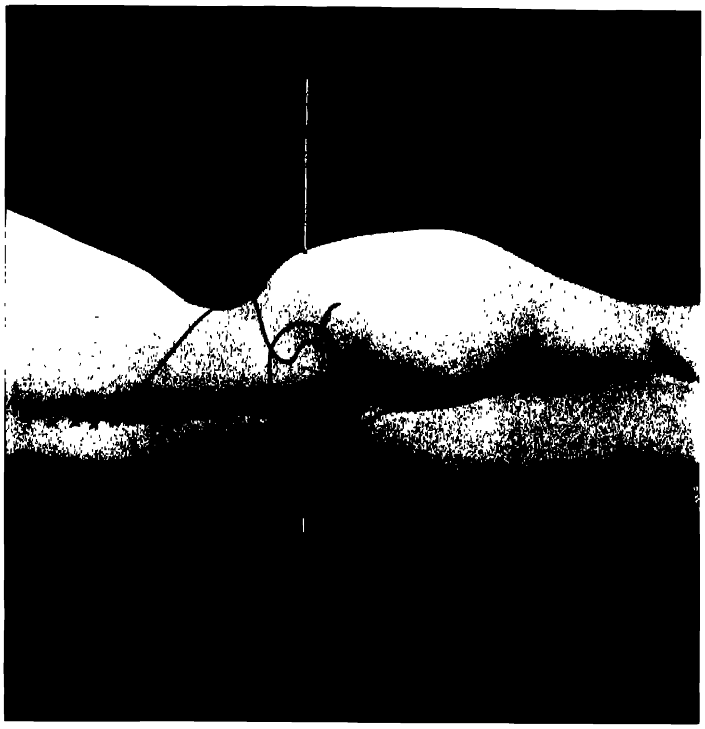
EXPOSURE FACTORS

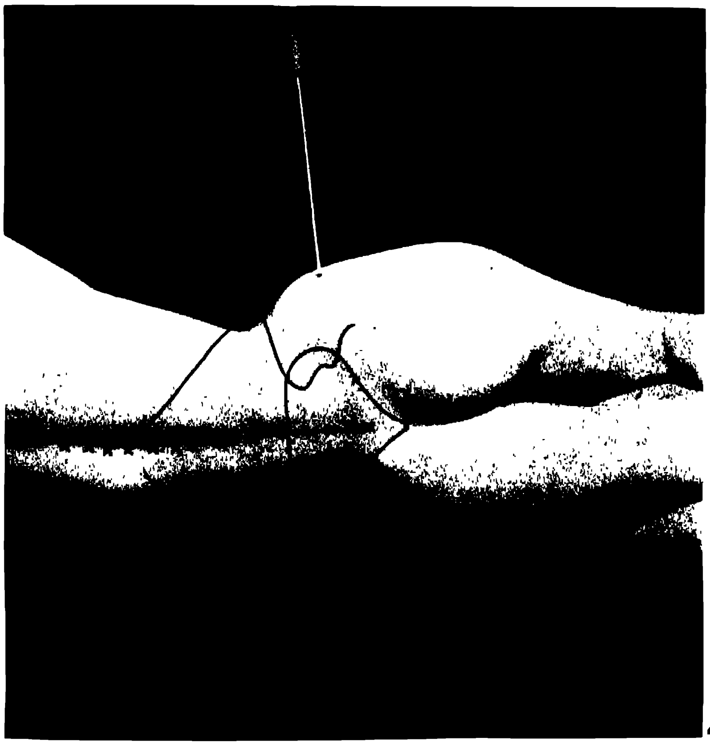
kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*66	38	23	30″	Ilford	Tungstate	-
65	103	62	36″	Ilford	Tungstate	Stationary
65	150	90	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 · 10 in.

* Ward mobile unit.

NOTE—The less experienced radiographer who finds it a little difficult to obtain the correct angle and relationship between tube, subject, and film, may centre with the tube straight above the symphysis pubis, allowing the oblique instead of the central ray to pass through the sacrum. In these circumstances a 30 inch anode-film distance should be used, the localising cone discarded, and the film displaced toward the head, with the upper border of the cassette at the level of the fourth lumbar vertebra, thus allowing for the oblique projection of the sacrum.


414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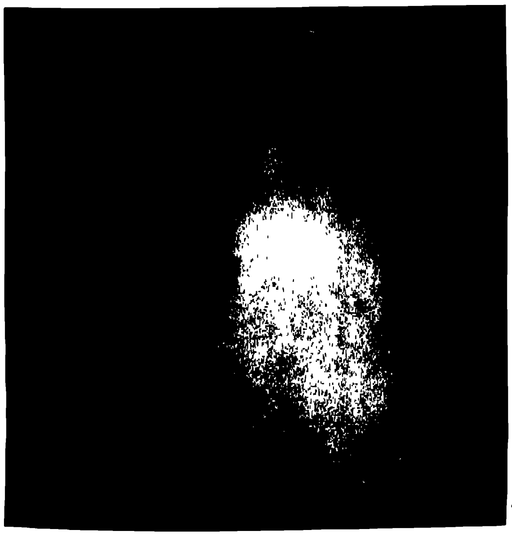

416

Spine: Sacrum

LATERAL

The patient is placed in the lateral position, with flexion at hips and knees, and with the raised leg supported at hip level in front of the lower limb. The patient will appreciate a wool pad placed between the hip and couch.

Care should be taken to see that the trunk is in the true lateral position, with the long axis of the sacrum parallel to the film, this adjustment being obtained by raising the trunk on a firm pad placed under the mid-lumbar region (**414**). Alternatively, the tube may be angled toward the feet, to bisect the long axis of the sacrum at right angles (**415**).

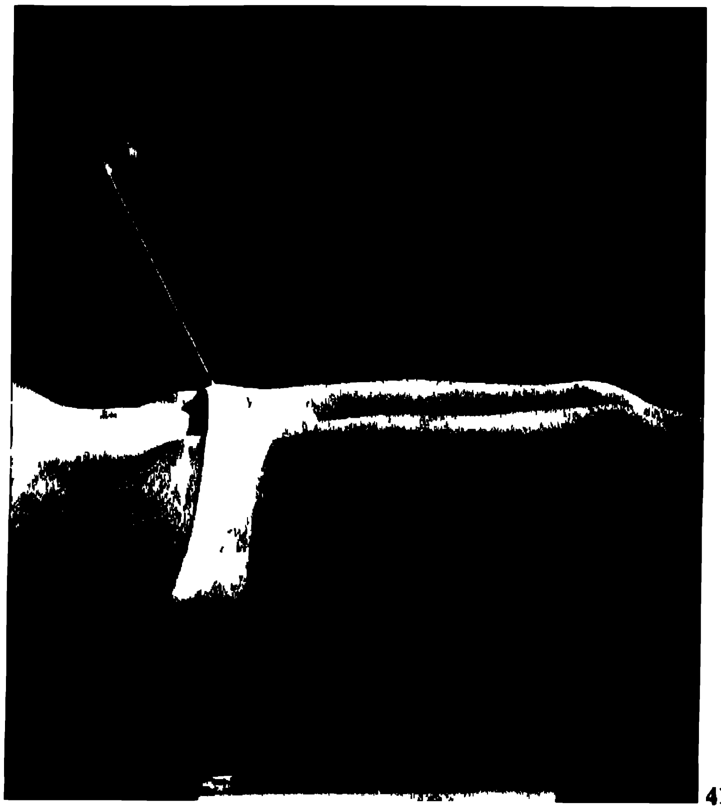
CENTRE 3 inches forward from and at the level of the posterior inferior iliac spine. The position of the iliac spine can be determined by following the line of the crest to the posterior aspect, where iliac bone and sacrum meet to form the sacro-iliac joint. The positions of the posterior iliac spines are frequently marked, especially in the male, by dimples.

(414, 415, 416)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
86	400	240	36″	Ilford	Tungstate	Potter-Bucky
86	190	115	30″	Ilford	Tungstate	Stationary
86	265	160	36″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 12 × 10 in.


417


418

Spine

Coccyx

The coccyx, consisting of four vertebral segments fused together at the termination of the vertebral column, is often rudimentary in form: it is quite superficial, and curves downward and forward, the most satisfactory antero-posterior view being obtained when the tube is angled toward the feet. In many cases, however, it is shown very well in the ordinary view of the sacrum when not obscured by the pubic bones or by fæcal and gas shadows. The initial preparation is often unsatisfactory, and preparation may have to be repeated to free the lower bowel of gas and fæces.

ANTERO-POSTERIOR

The patient is supine, being in the same position as for the antero-posterior view of the sacrum.

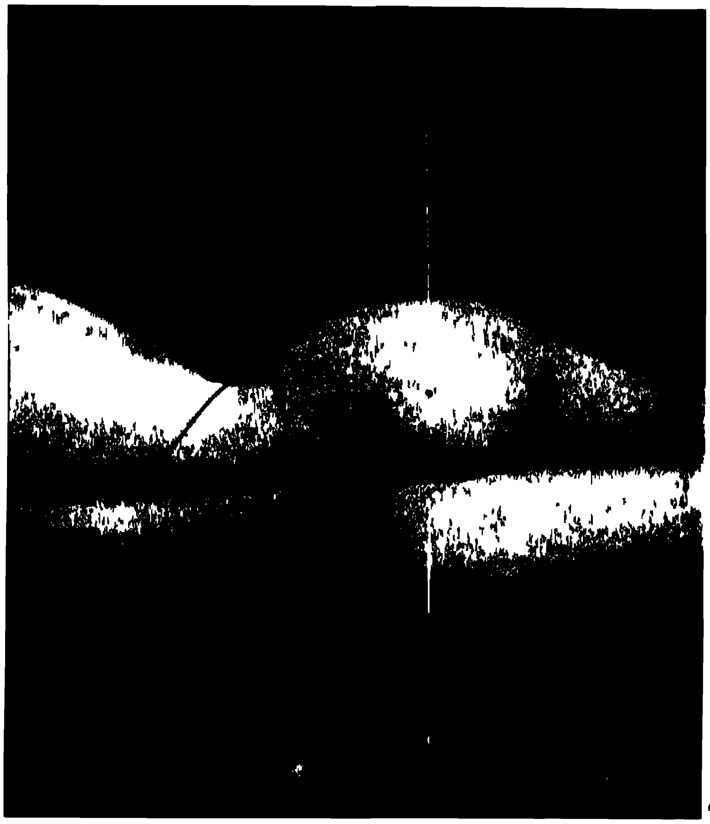
CENTRE in the mid-line, above the symphysis pubis. The tube is angled 10 degrees toward the feet to separate the coccyx from the shadow of the symphysis pubis.

(417, 418)

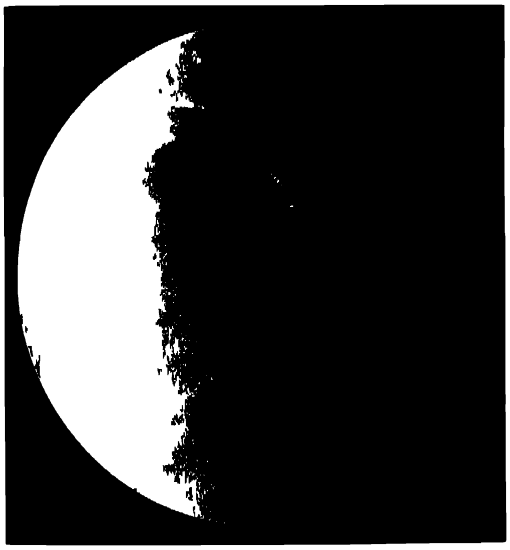
EXPOSURE FACTORS						
kVp.	mA Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	75	45	36″	Ilford	Tungstate	Stationary
65	115	70	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in

NOTE—The coccyx is shown reasonably well in the antero-posterior view of the sacrum when the tube is angled toward the head, but is then considerably foreshortened.



419



420

Spine: Coccyx

LATERAL

The patient is placed in the same position as for the lateral sacrum, with the coccyx over the middle of the couch.

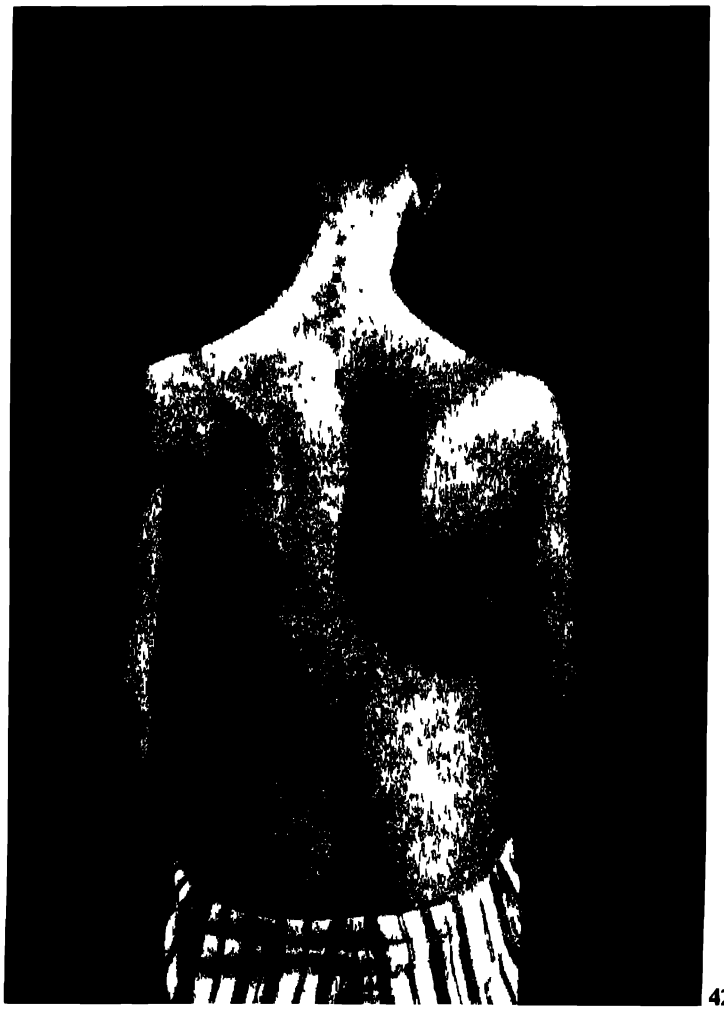
CENTRE over the coccyx, which may be felt between the buttocks.

(419, 420)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	137	83	36″	Ilford	Tungstate	Stationary
75	200	120	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 8 in

NOTE—In placing the patient in position it should not be forgotten that the coccyx is very superficial, and in order to include it on a small film it is necessary for the bone to be over the mid-line of the film with the tube centred directly over it; otherwise, owing to the great distance between the coccyx and the film, projection distortion may displace the shadow of the bone from the film. It is therefore an advantage to increase the anode-film distance to counteract the distortion accompanied by lack of definition due to subject-film distance, the use of a small localising cone being also of assistance.



421

422

Spine: Common Abnormalities

Scoliosis

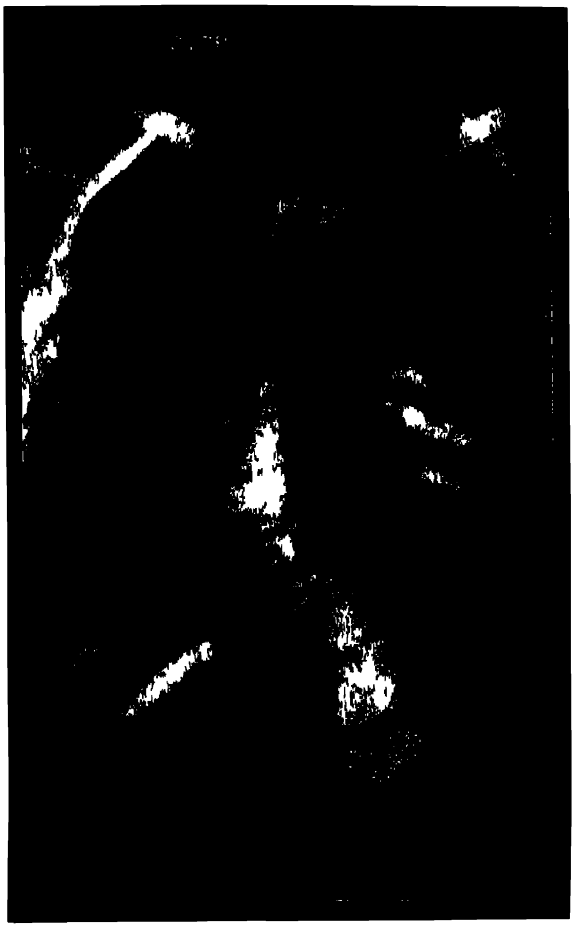
The term scoliosis indicates a lateral curvature of the spine with rotation, which may be the result of either postural or pathological causes, and usually the major part of the spine is involved as the initial curve gives rise to additional compensatory curves, as shown in the illustration (**421**).

In order to show the general alignment of the spine in these cases it is essential to include as large an area as possible on a single film. Should more than one exposure be necessary each film should include part of the adjoining area, so that when finished they may be overlapped in part, the two together reproducing the whole of the curve. For instance, a 17 inch by 14 inch film might include two-thirds of the curve, a 12 inch by 10 inch film serving to cover the remainder, but it would be far more satisfactory in such circumstances to use two 17 inch by 14 inch films, and so show the whole of each part of the curve on one film or the other, the two films together showing the whole curve (**423, 424**). The use of the narrow 17 inch by 7 inch spinal film is not advised, as variations shown in adjacent structures, which might be of importance, are excluded. A full-length view of the spine in the erect position is an advantage in these cases.

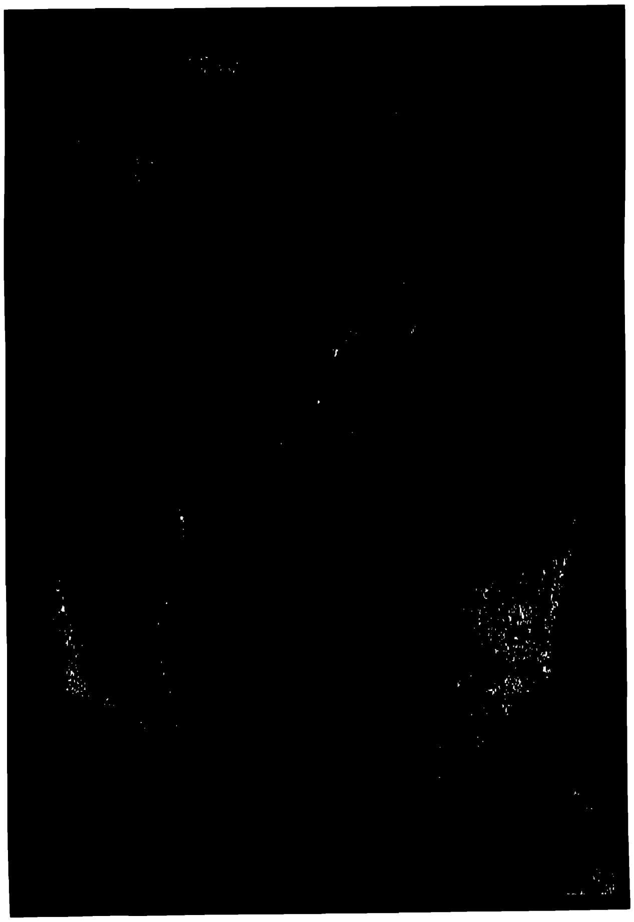
It is rarely possible to obtain a satisfactory general *lateral* view of the whole spine at a single exposure, but by careful manipulation it is possible to obtain a good lateral view of the individual bodies. This may be achieved by centring to the long axis of each part of the curve, taking each section in turn (**422**). This, however, is not necessary in every case, as the antero-posterior view may be found to give all the information required.

A re-examination is often required after an interval of time to show improvement or otherwise in response to treatment, and it is essential to be able to repeat the general position of the patient adopted at the initial examination in order that the repeat films may be precise duplicates of the first exposures and so facilitate close comparison. In the case illustrated the shoulders (**423**) and pelvis (**425**) were carefully adjusted to the true antero-posterior position, and that positioning was closely adhered to at subsequent examinations.

No two patients are alike, however, each presenting a new problem to be dealt with as circumstances may permit.

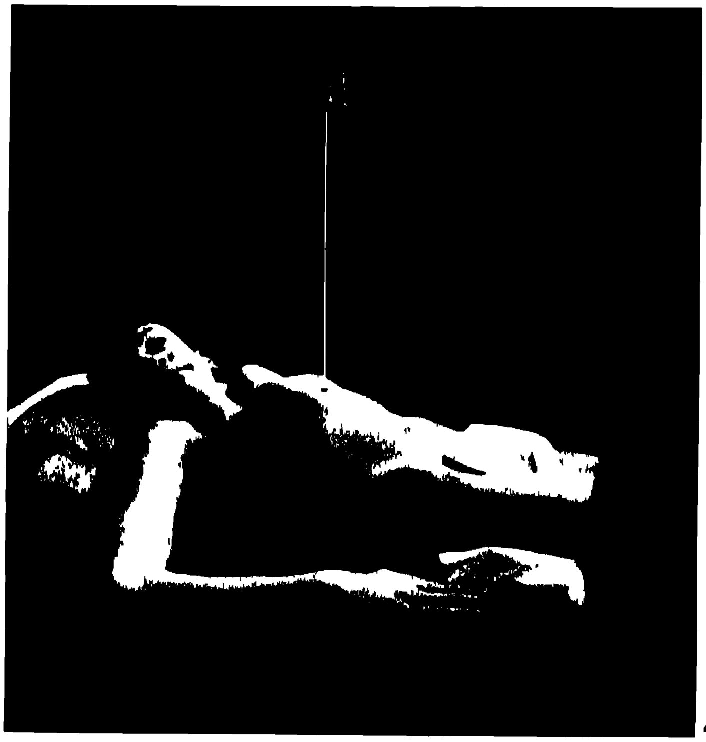

423

424


425

Kyphosis

Kyphosis of the spine is a dorsal curvature which may affect any region of the spine, and is due to deformity or collapse of one or more vertebral bodies, producing sharp angulation in the early stages and, later, the rounded appearance of the typical hunch-back. There is sometimes a combination of scoliosis and kyphosis.



426

ANTERO-POSTERIOR

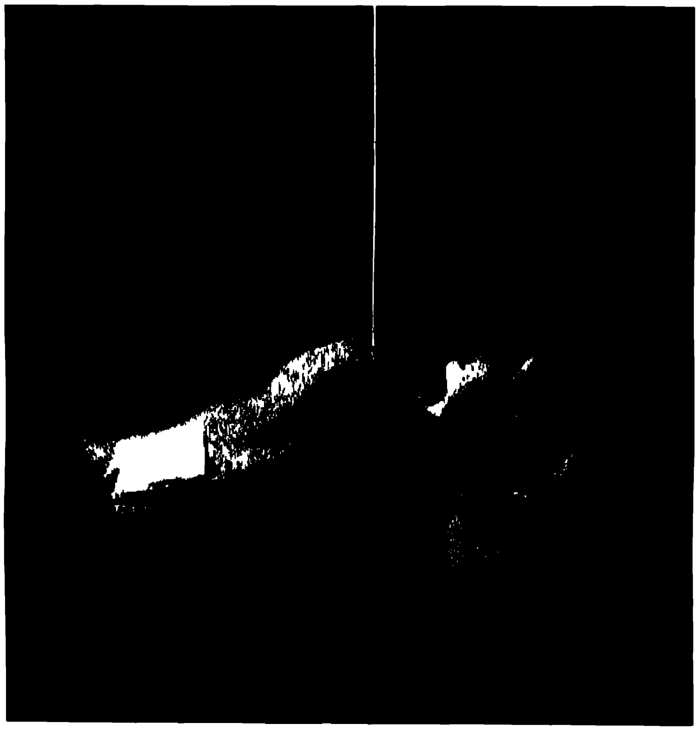
It is often difficult to obtain a satisfactory antero-posterior view, especially if there is a well-marked kyphosis.

These patients require careful manipulation to prevent painful pressure at the apex of the kyphosis. Soft wool bags and firm sandbags are used to support the trunk, as shown in the illustration (426). In the early, acute stages of the disease the kyphosis is less marked, but if the patient is being treated in a plaster bed and is turned over into the prone position on removal from the cast, satisfactory views may be taken from the postero-anterior aspect, as discussed on page 135.

In suitable subjects the erect position may be used, and pressure thus avoided, the patient being maintained in position by the Potter-Bucky compression band.

CENTRE to the apex, bisecting the angle of the kyphosis. (426, 427, 428)

In advanced cases it is necessary to increase the kilo-voltage considerably: this is usually in excess of what is required for the lateral view of the same patient.



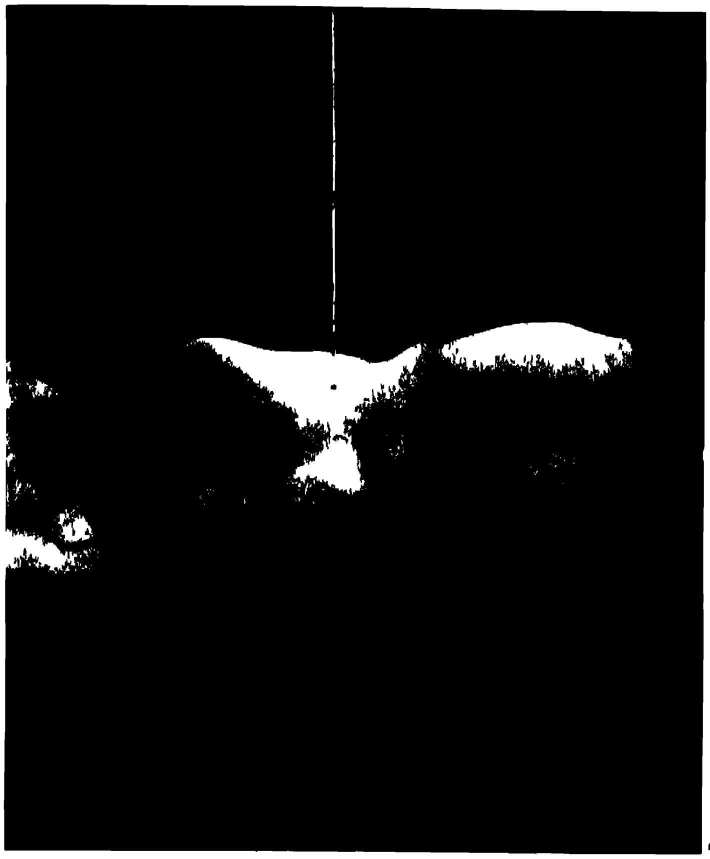
427

In early cases, when films for comparison are taken frequently, it is essential that each film should be taken from the same angle. To ensure this the patient should be closely adjusted to the same position for each examination. The shoulder and pelvic girdle are the best landmarks: these should be parallel to the couch, or the degree of variation noted from time to time.

These remarks may also be applied to the evidence required to show the variation in the size of an abscess surrounding the bone lesion, although the exposure factors to be applied in the case of a pronounced kyphosis may result in overshadowing of the abscess and an additional soft tissue film be necessary.

428

Spine: Common Abnormalities Kyphosis



429

LATERAL

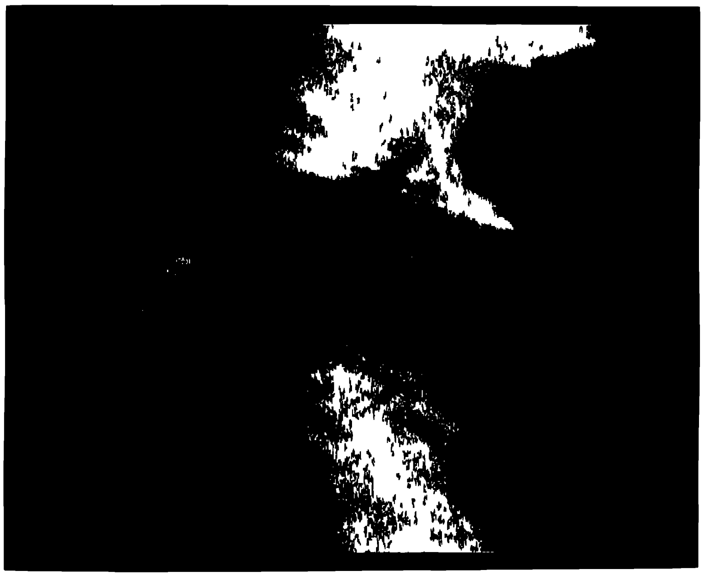
This position is often of greater value than the antero-posterior view as the condition of the collapsed vertebral bodies is clearly shown. The radiograph is also more easily obtained, and the position gives less discomfort to the patient.

In a well-marked kyphosis the bones concerned may be quite clear of other structures, so that the penetration and exposure required are considerably less than for the antero-posterior view.

The position is similar to that required for the ordinary lateral view of the spine, but an additional lateral adjustment is necessary to place the whole diseased area within the range of the X-ray beam and film. This is sometimes difficult to arrange on the curved Potter-Bucky couch, but soft wool bags and sandbags serve to steady the patient in position on the curved surface.

CENTRE within the apex of the curve of the kyphosis.

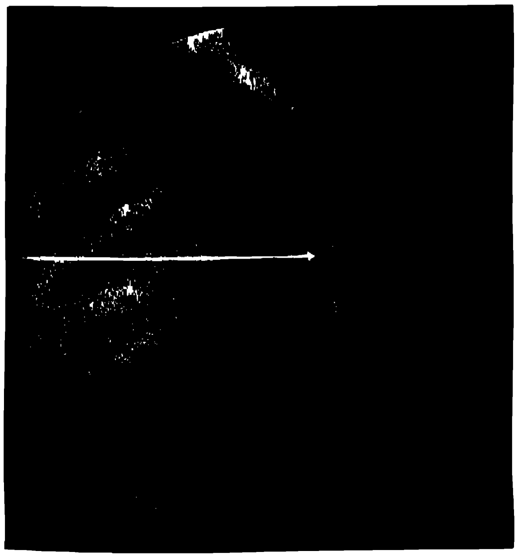
(429, 430)



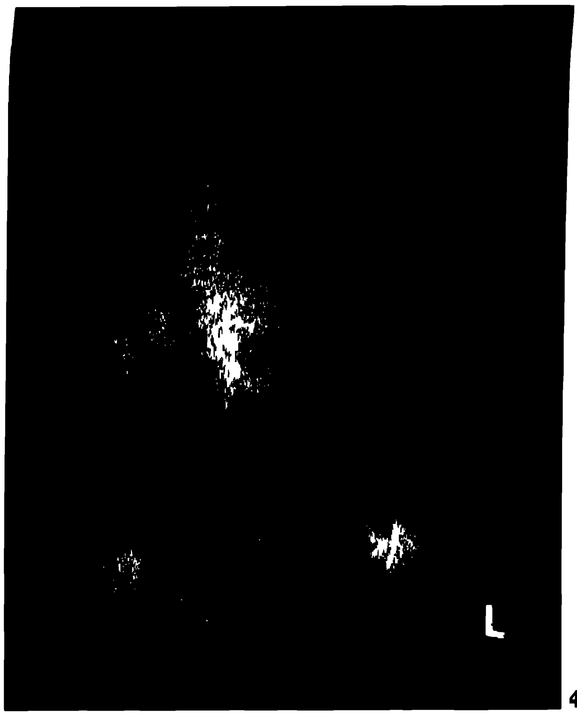
430

The additional lateral view (**431**) is included to show a typical lateral kyphosis of the spine without the complication of a scoliosis, as shown in the other kyphosis illustrations. The white line indicates the direction of the X-ray beam when centred to produce an antero-posterior view.

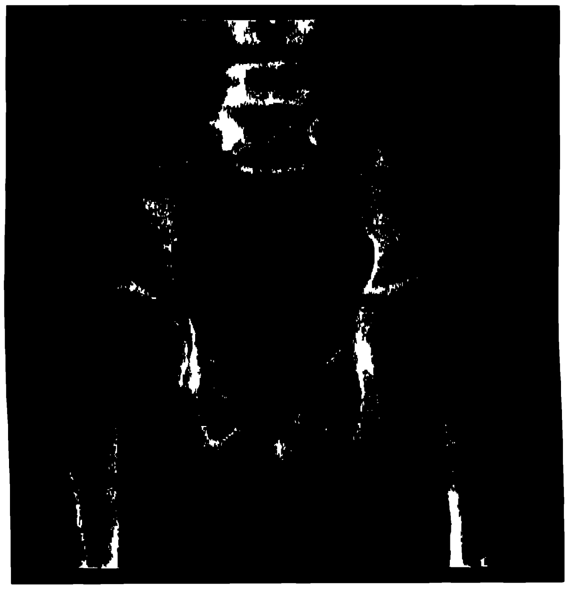
Lateral radiographs may be required of a patient who is under treatment by hyperextension and encased in a plaster cast. It is therefore not always possible to use the Potter-Bucky diaphragm unless a vertical grid is available. It is sometimes possible, however, to place a flexible cassette, such as is used in industrial radiography, inside the plaster jacket, opposite to the vertebral bodies being examined, by which means useful radiographs are obtained.



431



432


433

Cold Abscess Shadows

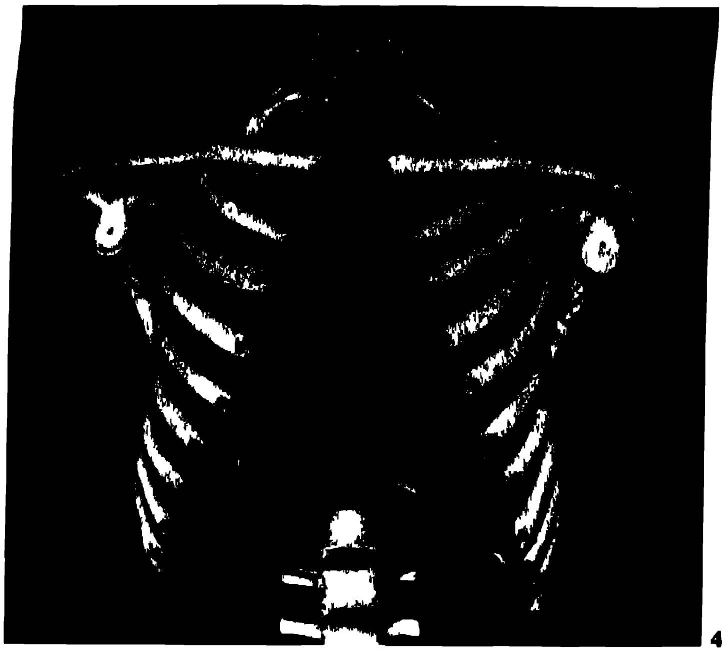
In spinal caries it may be necessary to show the presence of either a thoracic or psoas abscess. In the dorsal region, should there be a marked kyphosis, the penetration to show the bones will be too great for the softer structures. In this instance, therefore, two films should be taken, one of high penetration to show the bone, and one of low penetration to show the soft structures. Should it be necessary to take a series of films over a long period, care should be taken, in placing the patient, to adhere to the one position, as rotation to right or left will show a false variation in the size of the abscess shadow.

In the lumbar region, where the question of a psoas abscess arises (**432**), rather more than the whole area of the psoas muscles should be included—the eleventh dorsal vertebra down to below the level of the lesser trochanter.

Illustration (**433**) shows the psoas passing over the crests of the ilium to its insertion in the lesser trochanter.

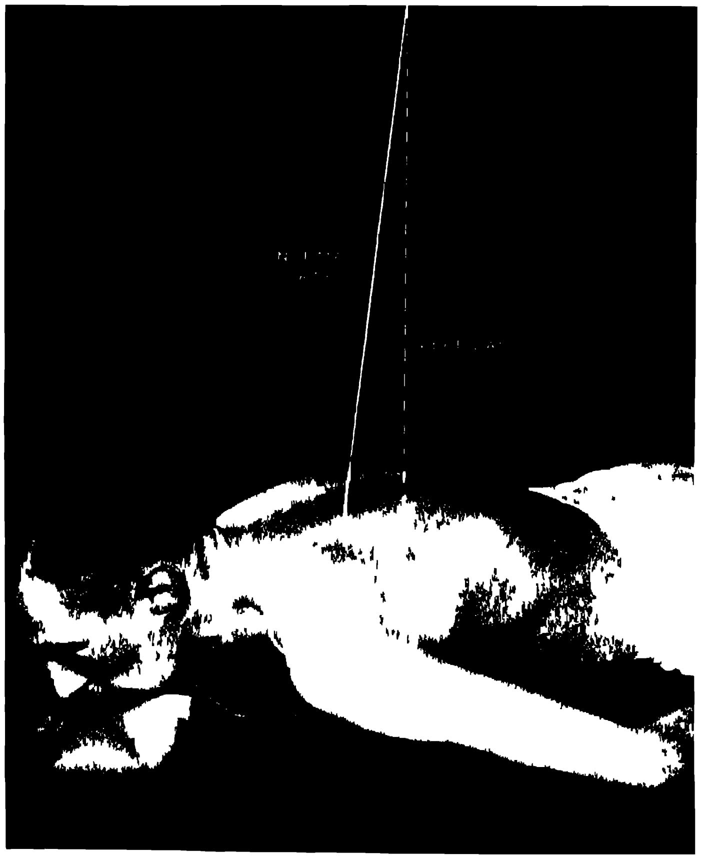
SECTION 8

Bones of the Thorax



434

435



436

SECTION 8

BONES OF THE THORAX

The bony thorax is formed by twelve pairs of ribs which articulate with the spine posteriorly, the upper ten also joining the sternum anteriorly, through the costal cartilages and forming a flexible cage enclosing the thoracic viscera (434). This section embraces the technique for the ribs and sternum.

All views may be taken with the patient in either the erect or the horizontal position.

The exposure factors quoted refer to an adult male subject weighing 140 pounds, having a height of 5 feet 7 inches and a thickness of chest, at the sternal angle, of 8 inches, and breadth, at the level of the axillæ, of 12 inches. For smaller or larger subjects the kilovoltage may be varied by from 5 kilovolts to 10 kilovolts, or the milliampere-seconds by from 25 per cent. to 50 per cent.

Sternum

The sternum or breast bone is in three parts, the manubrium, body and xiphoid process. It is thin, flat and elongated in shape and quite superficial, so that the chief regions of radiographic interest may be felt. These are the "sternal notch," formed by the superior border of the manubrium, the "sternal angle," formed by the junction of the manubrium with the body at the level of the second costal cartilage, and the xiphoid process, which varies in shape considerably and is often quite rudimentary in form.

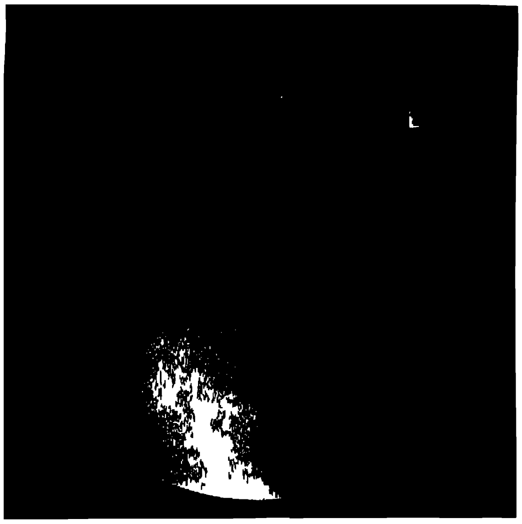
From the antero-posterior aspect the sternum is obscured by the third to the ninth dorsal vertebræ, and it is therefore necessary to make an oblique projection in order to separate it from the spine shadow.

The projection may be made either to the right or the left of the spine, but the displacement should not be so great as to cause undue distortion in the radiograph: the sternum and spine should be parallel (435).

There are two methods of taking the postero-anterior view, either (1) with the trunk straight and the tube off-centred and angled toward the spine when necessary; or (2) with the trunk angled and the tube straight.

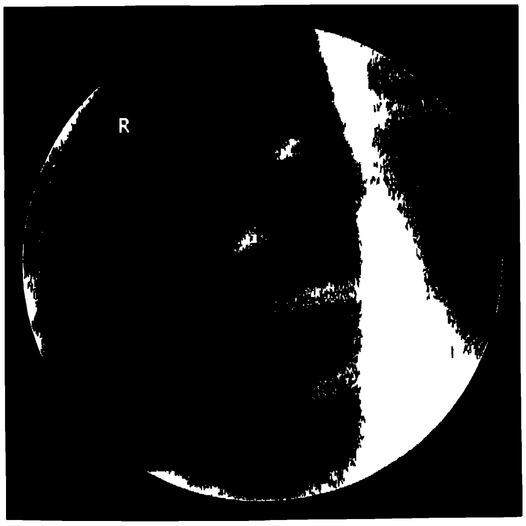
In each instance the anode-film distance is minimised in order to diffuse the shadows of the ribs, which would otherwise confuse the sternal image: the lung shadows may be still further diffused by allowing the patient to breathe quietly during a *long exposure* given at a relatively *low milliamperage* (435).

Comparison should be made of radiographs (437 and 439), exposed for a half-second during arrested respiration, with radiographs (438 and 440), exposed for 10 seconds during quiet respiration.

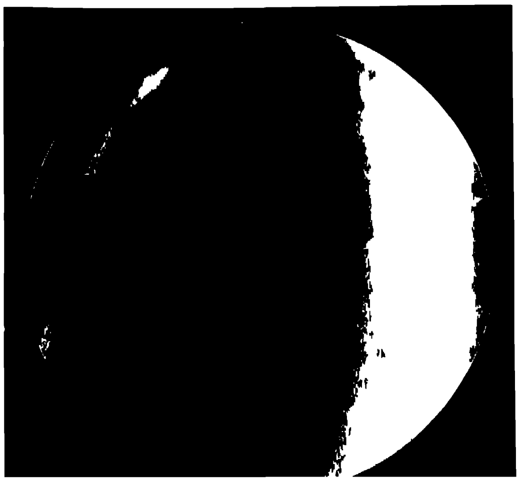


437

438



439



Bones of the Thorax: Sternum

POSTERO-ANTERIOR—(1) Trunk straight, with tube displaced.

The patient is placed facing the film, with the chin over the upper border of the cassette. When the horizontal position is used the top edge of the cassette is raised on a block of wood and the chin supported on a small sandbag **(436)** Immobilisation by the firmly applied Potter-Bucky compressor band is imperative. The position of the tube is calculated by the method adopted for the examination of the sterno-clavicular joints (page 51), the anode-film distance being adjusted to three times the thickness of the subject

CENTRE at the level of the sternal angle, with the tube displaced to one side of the spine to the extent of the estimated thickness of the patient; from this position the tube is angled toward the sternum, the normal ray passing approximately 3 inches to the tube side of the spine.

(436, 437, 438, 439, 440)

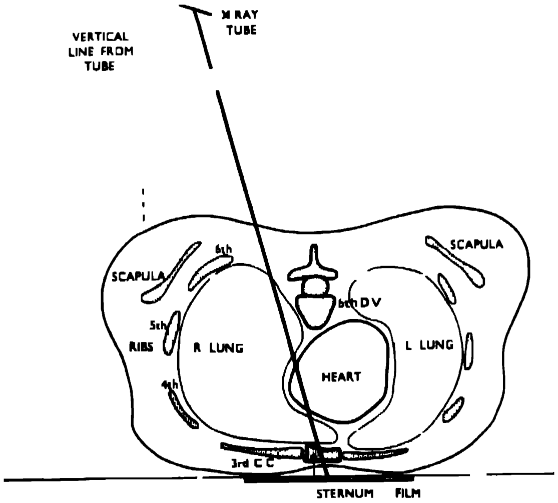
Exposure is made during quiet respiration, low milliamperage and long exposure time being employed.

(438, 440)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
45	*118	*70	24″	Ilford	Tungstate	
60	80	48	24″	Ilford	Tungstate	Stationary

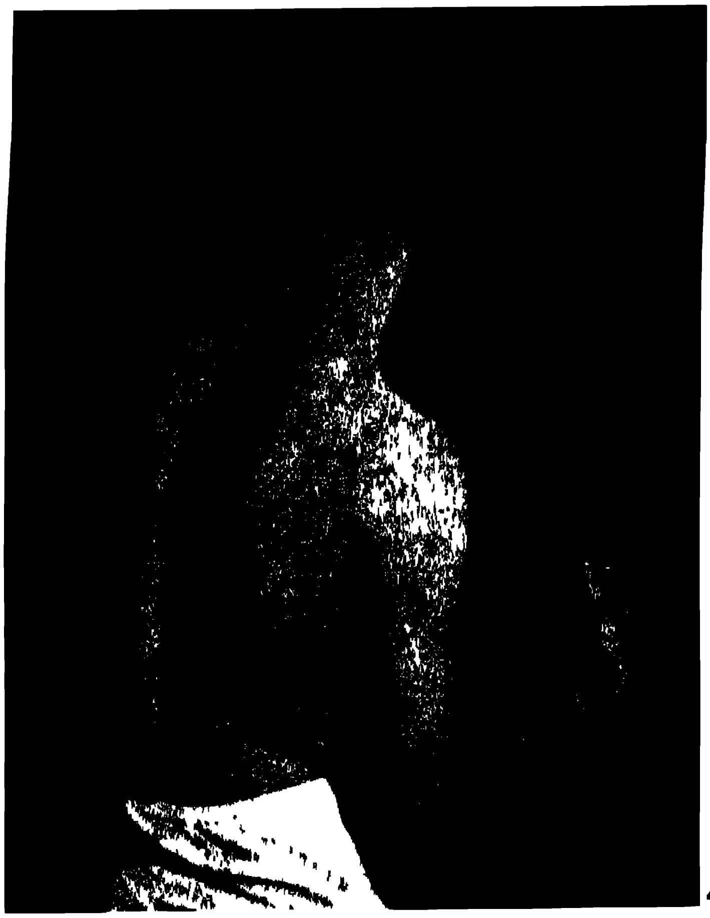
*10 mA employed   Cone to size of film, 10 × 8 in.

The cross-sectional diagram **(441)** illustrates this method of projecting the sternum clear of the spine shadow, in this instance a right oblique view **(439, 440)**.

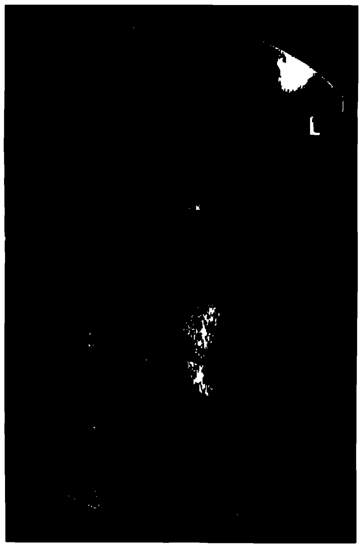


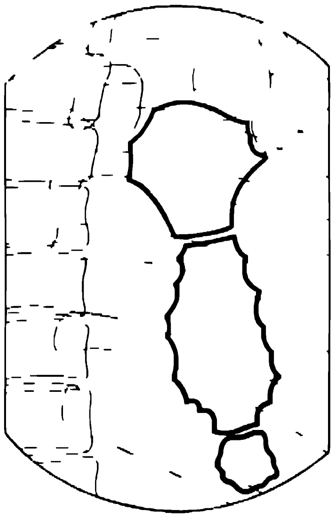
441

Bones of the Thorax: Sternum



442





443

444

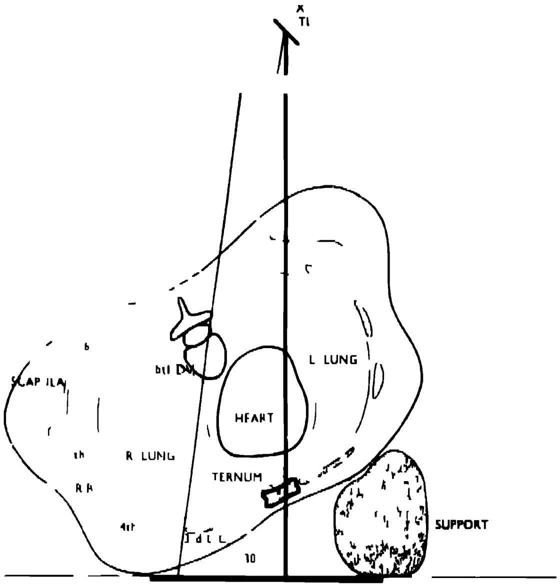
POSTERO-ANTERIOR — (2) Trunk angled, with tube straight.

Films may be taken with the trunk in either the right or the left oblique position, as shown in **(442, 446)**. For either side the patient is rotated away from the cassette through an angle of from 30 degrees to 40 degrees, and the arms are either placed beside the trunk or allowed to grasp the sides of the film support in order to steady the trunk.

CENTRE at the level of the fourth to fifth dorsal vertebræ, and from 4 inches to 5 inches away from the spine on the side turned away from the film.

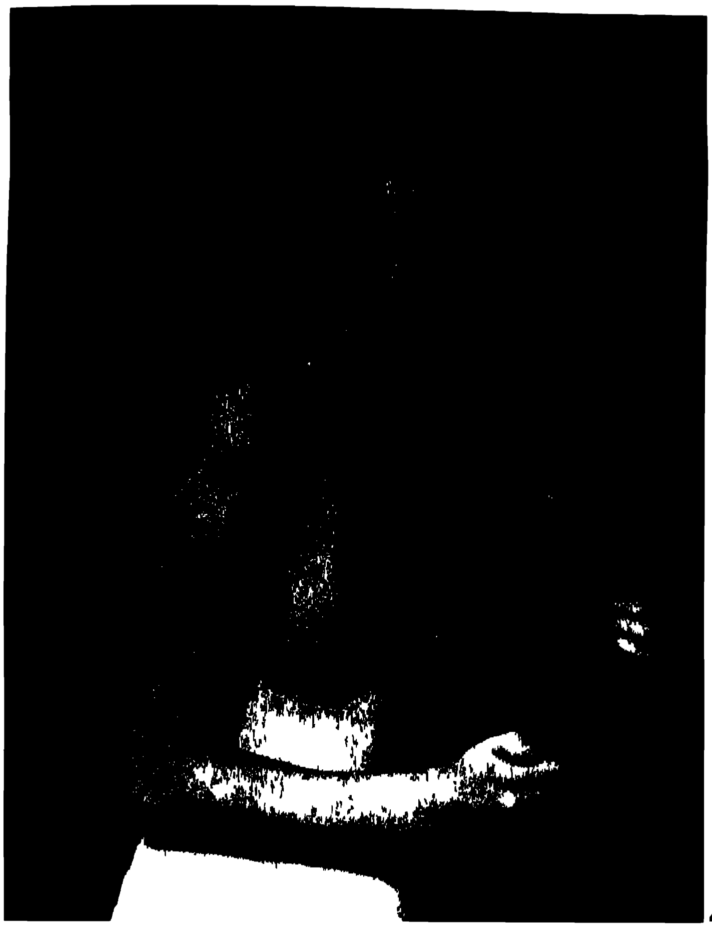
The axial ray passes through the sternum and falls upon the film at a right angle, as shown in the cross-sectional diagram **(445)**.

(442, 443, 444, 445, 446, 447, 448)

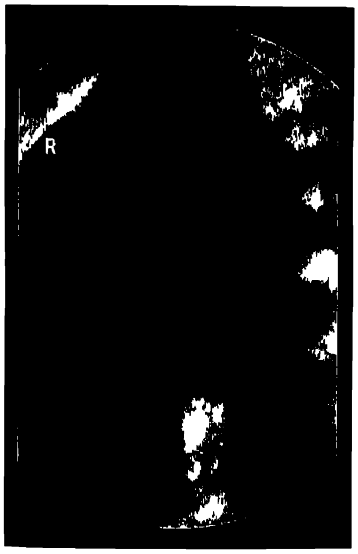


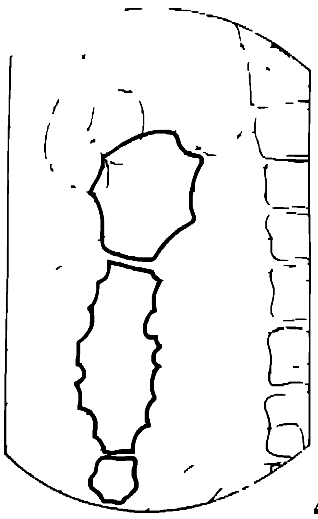
445

The diagram **(445)**, taken at the level of the sixth dorsal vertebra, shows the method of projecting the sternum clear of the spine shadow when the tube is straight and the trunk angled to the film.



446





447

448

Bones of the Thorax: Sternum

POSTERO-ANTERIOR (2) *(continued)*

As there is often some confusion in defining the *oblique position of the trunk* in relation to the *position of the organs shown in the resulting radiograph* when viewed from the film aspect, the following explanation of illustrations **(442-448)** is given. Reference should also be made to page 165.

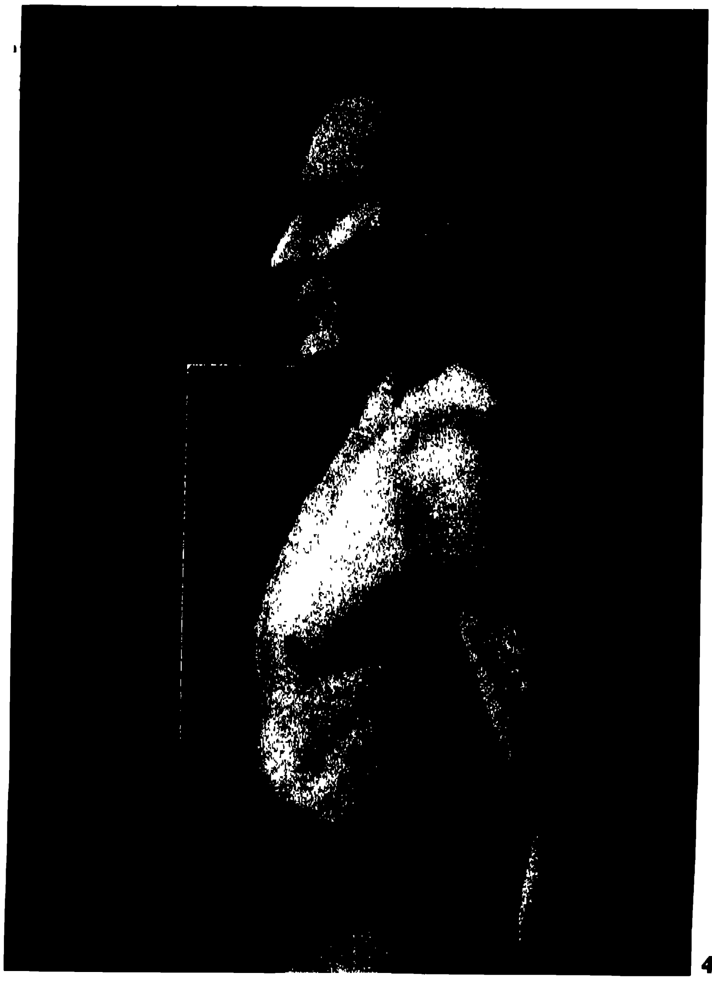
(442) *Right* anterior oblique position of the trunk, which allows the sternum to be projected to the *left* of the spine to overshadow the *left* thorax, as shown in the cross-sectional diagram **(445)**, and resulting in the *left* oblique radiograph of the thorax **(443)**, with explanatory tracing diagram **(444)**.

(446) *Left* anterior oblique position of the trunk, which allows the sternum to be projected to the *right* of the spine to overshadow the *right* thorax, resulting in the *right* oblique radiograph **(447)**, with explanatory tracing diagram **(448)**.

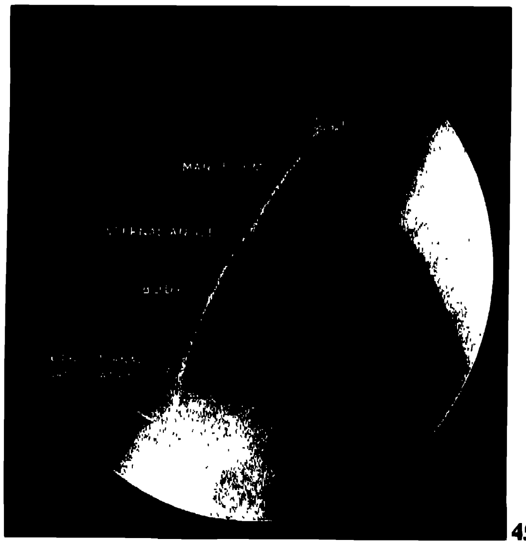
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
72	20	12	30"	Ilford	Tungstate	—
70	110	67	36"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 · 8 in. or 12 × 10 in.

Although these radiographs of the sternum are quite satisfactory for diagnostic purposes, they do not reproduce to advantage, hence the necessity for the accompanying tracing diagrams. Comparison should be made of **(443, 447** and **438, 440)**, when the advantage of skeletal immobilisation with gentle respiration during long exposure of the latter will be appreciated.



449



450

Bones of the Thorax: Sternum

LATERAL

The patient is placed with the broad plane of the sternum at right angles to the film and with the shoulders well back. General immobilisation is important, and is assisted by allowing the patient to sit with a pillow between the head and film support. When it is more convenient for the patient to stand, the feet should be separated to ensure balance.

A lateral lung exposure, at an increased kilovoltage, is usually most satisfactory in view of respiratory movements, exposure being made on inspiration when possible.

The anode-film distance is increased to compensate for the displacement between sternum and film.

CENTRE to the sternal angle.

(449, 450)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
85	33	20	60″	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in. or 12 × 10 in.

Bones of the Thorax

Ribs

The anatomical arrangement of the ribs, their relationship to adjacent organs and the effect of respiratory movements complicate radiographic investigation of these bones.

From posterior articulations with the vertebræ to the anterior extremities the ribs extend downward and forward to encircle the thoracic viscera, terminating toward the anterior aspect of the trunk, with the exception of the lower two pairs of "floating" ribs, which terminate posteriorly **(467)**. The respective *levels* of the anterior and posterior extremities of each rib differ by as much as from 3 inches to 5 inches **(451)**.

Connecting the ribs with the sternum are the costal cartilages, the articulations of which with the ribs are named costo-chondral articulations, and with the sternum the costo-sternal articulations. These cartilages increase in length from upper to lower and often throw a shadow in the adult because they are partly calcified. Imaginary lines adjoining the rib endings form an inverted

451

letter "V." Reference should be made to skeletal photograph **(451)**.

The diaphragm is a dome-shaped fibro-muscular septum separating the thoracic from the abdominal cavity and forming the floor of the former and the roof of the latter. It is sometimes well described as being similar in shape to an open umbrella, the area of attachment of the diaphragm to the trunk corresponding to the edge or circumference of the umbrella. Viewed from its own level the dome of the diaphragm overshadows the lower ribs, but respiratory movements allow a variation in level of the *dome* of from two to three inches. Also, the shape of the diaphragm and its mode of attachment to the trunk facilitate its projection above or below normal level according to the centring of the X-ray beam—whether high up over the chest or low down over the abdomen. These peculiarities of the diaphragm are of considerable importance in the radiographic examination of the ribs. **(454, 465)**

From either the antero-posterior or postero-anterior aspect, therefore, some of the ribs may be shown partly above and partly below the diaphragmatic shadow. As both densities are not easily shown on a single film it is necessary to decide whether the ribs in question should be projected to overshadow the lungs or the abdomen, that is to say, either above or below the diaphragm.

In addition, when localising down to the site of an injury it should be remembered that the whole length of each rib concerned should be included on the film, as the flexibility of the rib cage is such that a rib may be injured at a point remote from the site of the blow causing the injury. Thus, owing to the oblique direction of the ribs, when the site of trauma is anterior at least five inches above this region should be shown on the film in order to include the posterior termination of the rib under examination. On the other hand, when the injury is posterior the film should be so placed in position as to include the lower, anterior level. This applies also to groups of ribs, and is of particular importance when small films are used.

In some subjects all ribs may be shown above the diaphragm, and in all subjects the tenth rib will be included when the centring point is as high as the level of the third dorsal vertebra so that the diaphragm is projected downward by the oblique rays. This is facilitated by taking films on inspiration; but in cases of actual rib injury, however, only shallow breathing is possible.

It is always preferable to X-ray the patient *before* plaster strapping has been applied, otherwise minor injuries may not be shown owing to the opacity of the plaster, although it is still possible to show gross injuries. It is advisable, moreover, when necessary and convenient to do so, to send the patient back to the doctor in charge of the case for removal of such strapping.

Close collaboration generally with the Casualty and Out-Patients' Departments is essential in order to avoid waste of material and time and, what is more important, *unnecessary discomfort to the patient.* Plaster strapping is so often thoughtlessly applied in one department only to be removed, perhaps almost immediately, at the request of the X-ray Department.

452

Bones of the Thorax: Ribs

ANTERO-POSTERIOR

The patient is placed with the dorsal aspect of the thorax in contact with the film. The elbows are flexed, with the hands behind the hips, and the shoulders brought forward so that the upper arm structures and scapulæ may not obscure the rib shadows. This position is used when the anode-film distance is less than 36 inches and the injury is *posterior*.

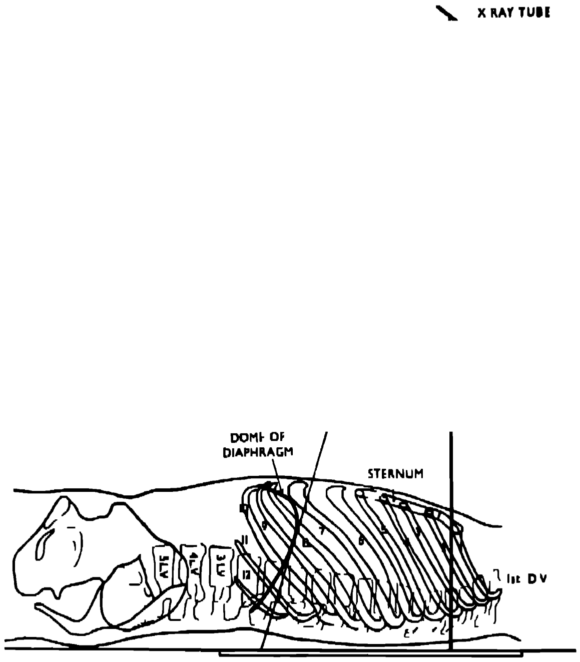
CENTRE to the sternal angle.

(452, 453, 454)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	8	5	30″	Ilford	Tungstate	
*65	13	8	30″	Ilford	Tungstate	—

Cone to size of film, 12 × 10 in, 15 × 12 in or 17 × 14 in
* Ward mobile unit

453



454

The diagram (454) shows the method of projection to include the maximum number of ribs *above the diaphragm*, using a high centring point, the exposure being made, on inspiration, from an anode-film distance of 36 inches. Reference, for comparison, should be made to diagram (465).

Bones of the Thorax: Ribs

455

456

457

POSTERO-ANTERIOR

The patient faces the film, the arms being abducted, flexed at the elbow joint and encircling the film: the chin is allowed to rest over the top edge of the cassette. This position is used when the injury is *anterior* and the anode-film distance less than 36 inches. It is also applied for both aspects of the thorax generally, and when teleradiography is employed, as for lung technique.

CENTRE to the fourth dorsal vertebra.

(455, 456)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	33	20	60″	Ilford	Tungstate	–
*65	18	11	36″	Ilford	Tungstate	

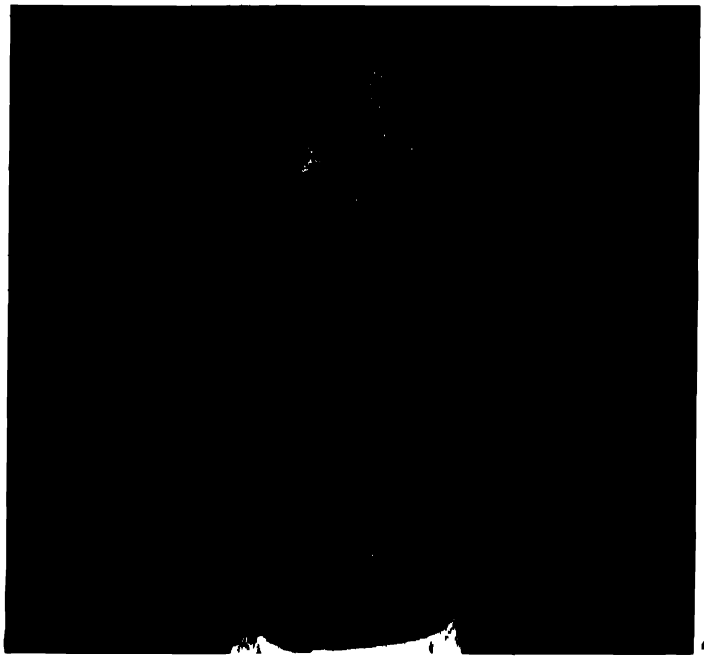
Cone to size of film, 12 × 10 in., 15 × 12 in. or 17 × 14 in.
* Ward mobile unit.

Two films taken of the same subject show the appearance of the ribs and diaphragm and the difference in density when taken on inspiration (456) and expiration (457).

Any advantage as between antero-posterior and postero-anterior views, depending upon the site of the injury, only occurs when short-distance technique is applied, the distal ribs being diffused and the proximal ribs clearly defined. On exposing at from 5 feet to 6 feet, as for lung technique, all ribs are equally well shown in both views, but the advantage is, perhaps, with the postero-anterior position (455), the scapulæ being then more satisfactorily projected clear of the rib fields.

The kilovoltage should be such as to produce a fairly flat type of negative in order to eliminate as far as possible the inevitable contrast produced by the varying densities in the thorax, allowing the rib regions of the axillæ, the heart, lungs and great vessels to be equally well demonstrated.

Any group of ribs which can be immobilised may be exposed during quiet respiration, applying long exposure time and low milliamperage, the resulting diffusion of the lung shadows enabling greater bone detail to be shown in the ribs concerned.



458

459

Bones of the Thorax: Ribs

OBLIQUE

From the antero-posterior or postero-anterior aspect a minor injury in the axillary line of the ribs may not be shown, but the oblique position allows this region to be demonstrated satisfactorily.

Each side is taken separately as required.

The patient is placed with the dorsal aspect of the trunk toward the film and then turned through an angle of approximately 45 degrees, the affected side remaining in contact with the film.

Any difficulty in judging the correct degree of rotation of the trunk may be settled by placing a set square having a 45 degree angle between patient and film support, as shown in the cross-sectional diagram (462).

The arms should be separated from the trunk, especially on the injured side, where some abduction, with the hand grasping the film support, assists immobilisation. When the condition of the patient permits, the hands may be clasped behind the head.

(458, 460)

A short exposure technique is applied, with intensifying screens, but the grid is usually omitted.

CENTRE through the sternum, at the level of the sternal angle.

(458, 459, 460, 460a, 462)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	16	10	30"	Ilford	Tungstate	—
*65	24	15	30"	Ilford	Tungstate	—

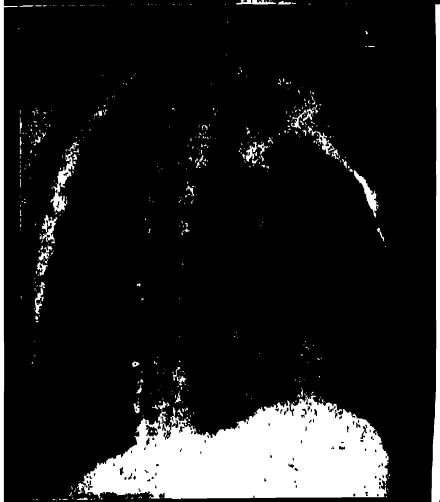
Cone to size of film, 12 × 10 in. or 15 × 12 in.
* Ward mobile unit.

In taking the left oblique view the dense shadow of the heart should be taken into consideration and the exposure factors adjusted accordingly, an increase of 5 kilovolts being suitable.

The anode-film distance should not exceed 30 inches, since, to ensure a satisfactory projection, it is necessary to make full use of the oblique rays to cover the convexity of the ribs in their relationship to the X-ray tube.

Bones of the Thorax: Ribs

460

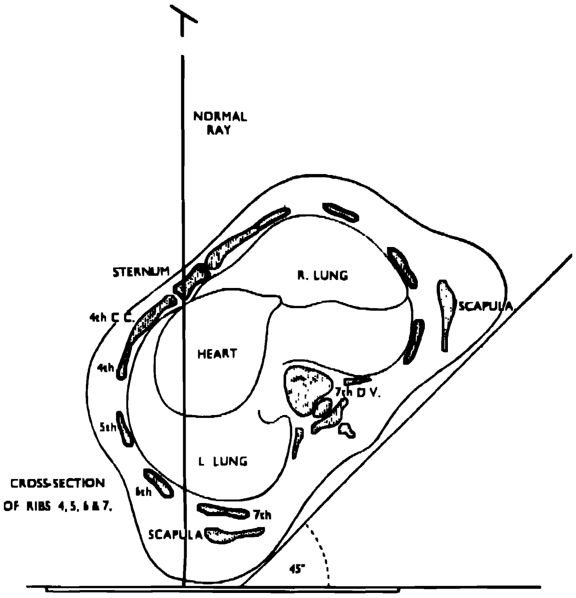


460a

461

OBLIQUE *(continued)*

These two positions of the trunk are described **(458)** as *right posterior oblique*, resulting in *right* oblique radiograph **(459)**, and **(460)** as *left posterior oblique*, diagram **(462)**, resulting in *left* oblique radiograph **(460a)**.



462

The cross-sectional diagram **(462)** shows the relationship between ribs, film and tube when the patient is placed in the *left* posterior oblique position to demonstrate an injury to the ribs in the *left* axillary line.

Comparison should be made with the anterior oblique positions and resulting radiographs shown on pages 158 and 159. It will be seen that all radiographs are viewed conventionally as from the anterior aspect of the patient.

FRACTURE RADIOGRAPHS

In the antero-posterior position **(452, 461)** the fracture of the rib in the right axillary line is barely visible, but in the antero-posterior right oblique position **(458, 461a)**, the fracture is seen clearly against the shadow of the lung.

Bones of the Thorax

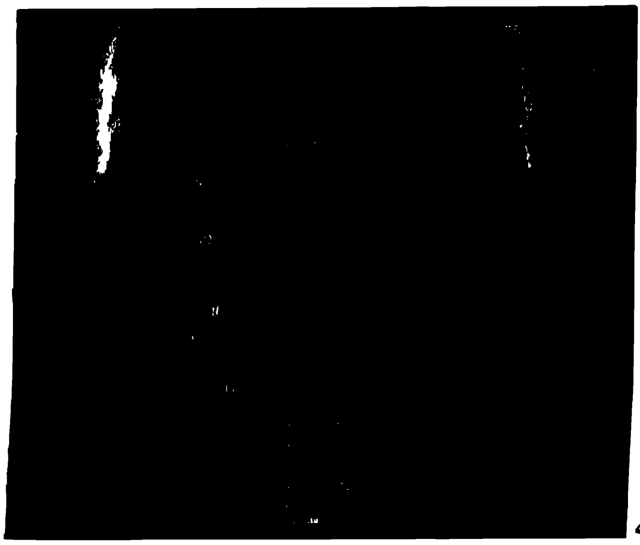
Lower Ribs

When the injury is confined to the lowest four pairs of ribs it is obviously more satisfactory to project them all below the level of the diaphragm. These ribs are always shown well in radiographs of the renal tract and lumbar spine, a particularly good example of the latter being shown on page 134. A similar centring point is therefore indicated, and, instead of centring over the site of the injury, the level of the lower costal margin is used. The difference in the relative levels of the diaphragm and ribs, according to tube centring and respiratory conditions, is shown in the accompanying illustrations:—

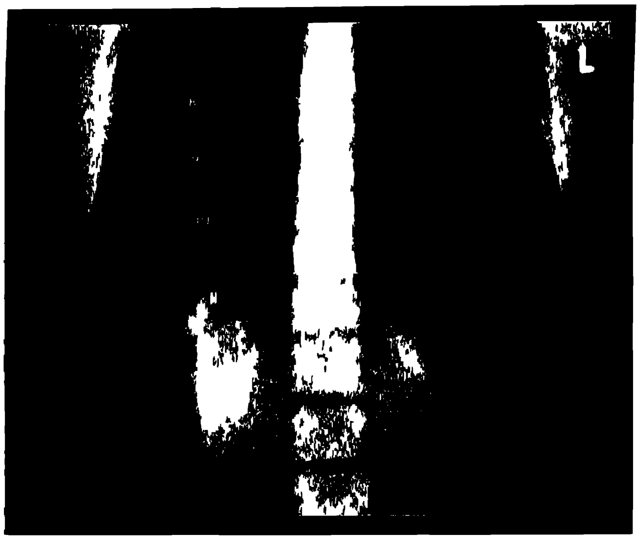
(463), taken on *expiration*, with the tube centred over the lower costal margin, as seen also in diagram **(465)**, which shows the dome of the diaphragm at the level of the eighth to ninth dorsal vertebræ: and

(464), taken on *inspiration*, with the tube centred at the level of the sternal angle, as seen also in diagram **(454)**, which shows the dome of the diaphragm at the level of the tenth to eleventh dorsal vertebræ

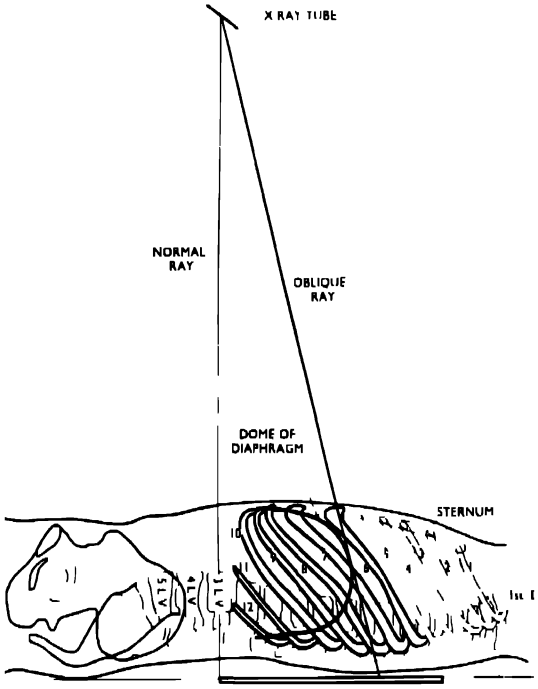
In each radiograph **(463, 464)** a 36 inch anode-film distance was employed, the same region being covered in each film, namely, from the sixth dorsal vertebra to the third lumbar vertebra, the main difference being the variation in diaphragm level.



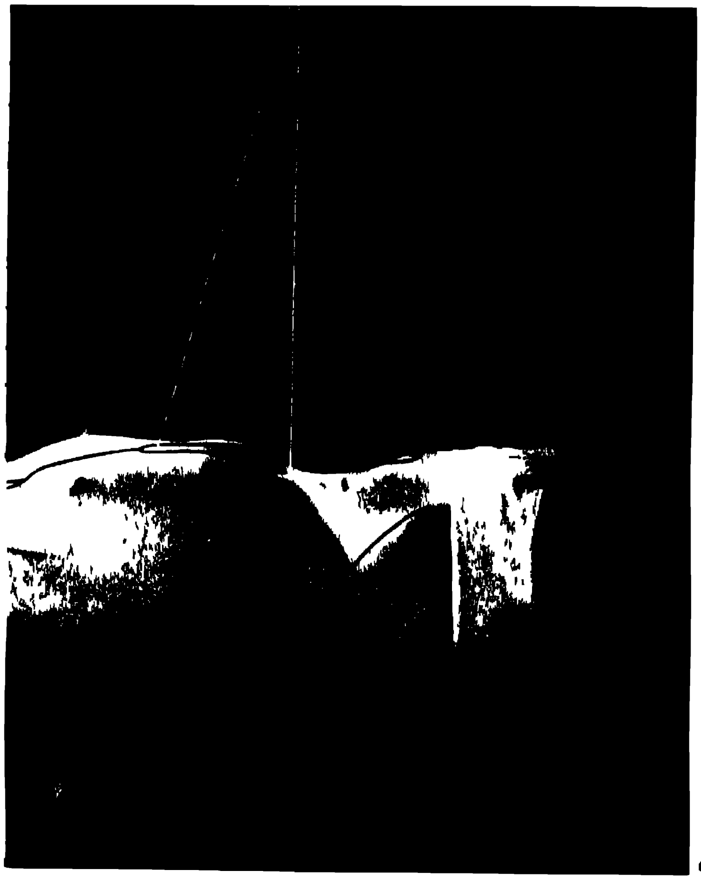
463



464



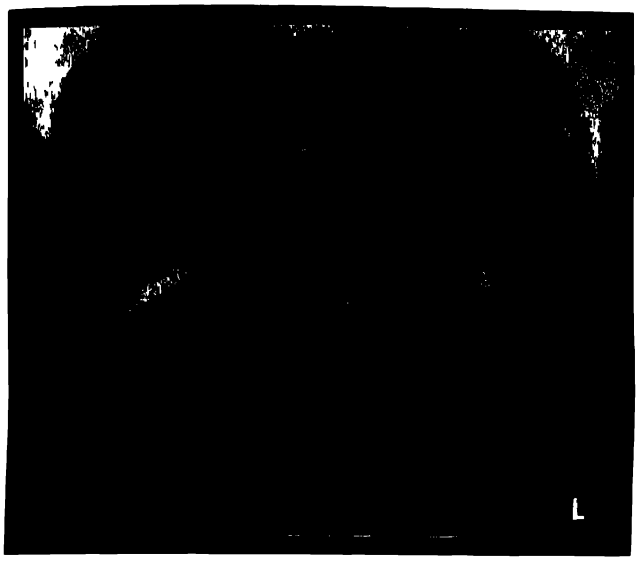
465



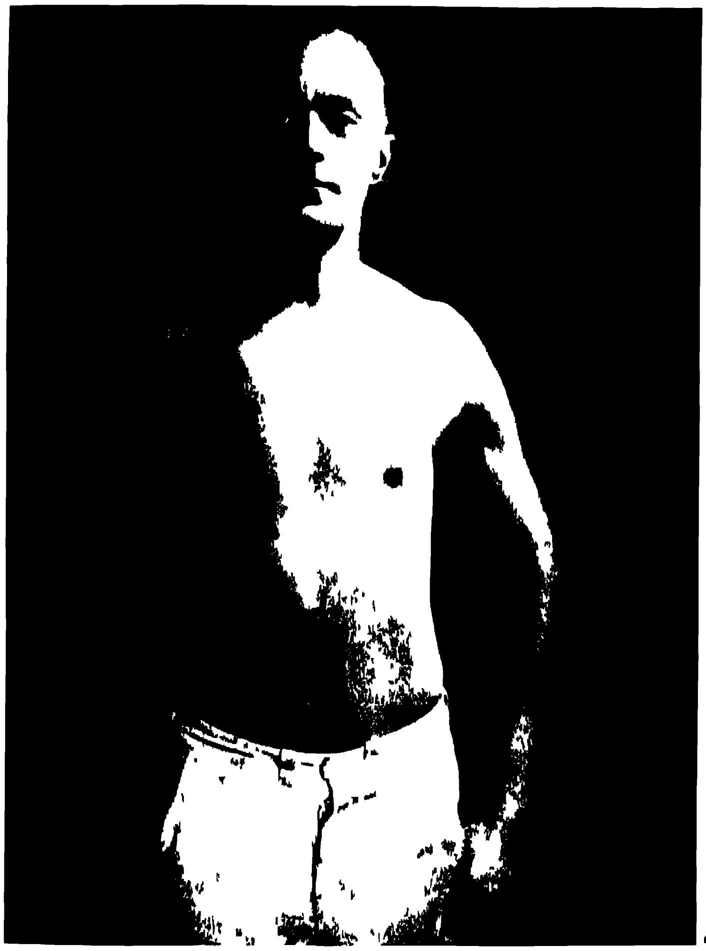
466

The diagram **(465)** shows the method of projecting the diaphragm to overshadow the greatest number of ribs by utilising the oblique ray from a low centring point, with the dome of the diaphragm at its highest level on expiration.

Bones of the Thorax: Lower Ribs



467



468

ANTERO-POSTERIOR

The patient is placed in the supine position (466) on the Potter-Bucky couch, a large cassette being placed transversely to include the whole of both right and left sides from the nipple line to the lower costal margin.

In dealing with the lower ribs it should be remembered that the bony ribs terminate toward the lateral aspects of the trunk, and that the anterior costal margin, which is felt from the first to the third lumbar level, consists of cartilage and is therefore not usually opaque to X-rays.

The eighth to twelfth lower ribs are best radiographed on the Potter-Bucky diaphragm, with the film posterior, whether the patient is in the horizontal or erect position. (466, 468)

CENTRE in the mid-line of the third lumbar region. This is also the lowest level of the cassette. (465, 466, 467, 468)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*67	17	10	30″	Ilford	Tungstate	
65	165	100	36″	Ilford	Tungstate	Potter-Bucky
75	145	88	48″	Ilford	Tungstate	Potter-Bucky

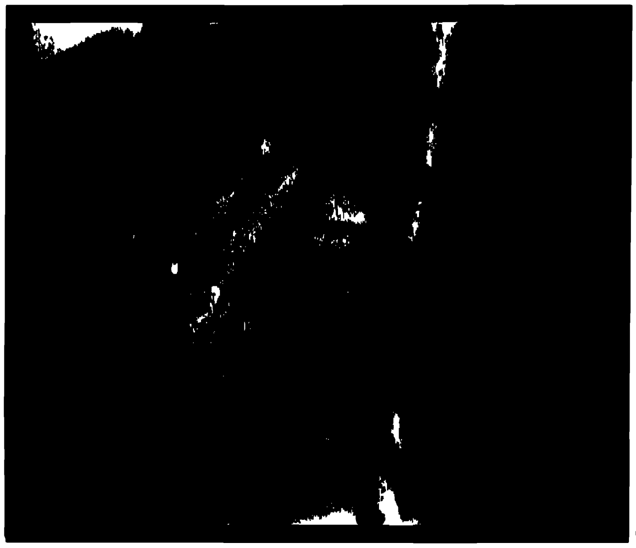
Cone to size of film, 15 × 12 in. or 12 × 10 in.

* Ward mobile unit.

Preparation of the patient, to evacuate the bowel of gas and fæcal shadows before the X-ray examination of the lower ribs, would be an advantage, but as the majority of these are casualty patients for rib injuries, it is not always possible to delay the examination for the requisite time.

Bones of the Thorax: Lower Ribs

469



470

LATERAL

The patient is placed in the true lateral position in relation to the film, with the arms well forward or folded over the head, so that they may not obscure the ribs.

Either the erect or the horizontal position may be used.

CENTRE mid-way between anterior and posterior borders of the trunk at the level of the lower costal margin, to which level also the lower edge of the cassette is adjusted.

(469, 470)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	396	240	48″	Ilford	Tungstate	Potter-Bucky

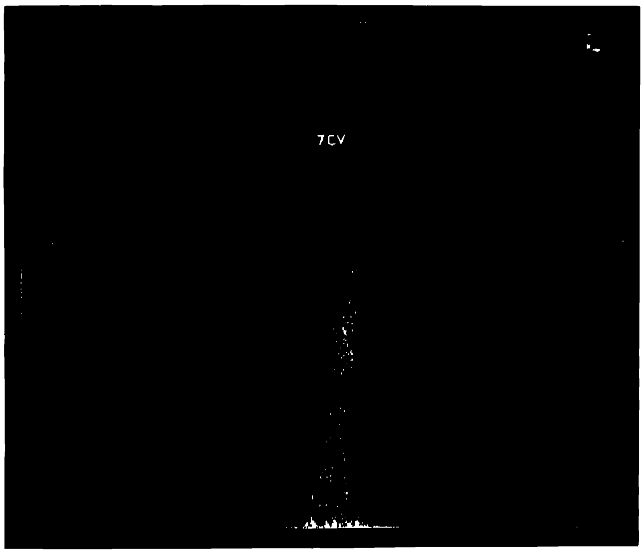
Film, 15 × 12 in. or 12 × 10 in.

When a localising cone is employed it should be of large covering capacity to include the film displacement in relation to the X-ray tube, otherwise an open field is advised.

When right and left ribs are to be equally demonstrated, a minimum anode-film distance of 48 inches is essential. The small degree of enlargement distortion shown at this distance is sufficient to allow differentiation between the two sides (470), whereas at the smaller distance of 30 inches there is considerable diffusion of the ribs nearest the X-ray tube.

The anterior extremities and distal thirds of the lowest six pairs of ribs are well demonstrated in this view.

471



472

Bones of the Thorax: Ribs

Abnormalities

Occasionally abnormality in the form of additional ribs is met with in the seventh cervical and first lumbar region. To demonstrate the presence of lumbar ribs with any certainty it is necessary to take antero-posterior radiographs of the entire dorsal and lumbar spine, as described under SPINE, Sections 6 and 7. This also applies to the absence of the twelfth ribs, which condition seems to be present in radiograph (377), where the appearance is that of six, instead of five, lumbar vertebræ.

Cervical Ribs

The region affected is the seventh cervical vertebra. The area involved is that from the fifth cervical to the fifth dorsal vertebra, including right and left sides equally. The erect position is usually possible for this type of patient, and is preferable for the lateral view.

ANTERO-POSTERIOR

The patient is placed facing the tube, with the chin slightly raised. It is important to ensure that the transverse plane of the trunk is parallel to the film.

The 10 inch by 8 inch film is placed transversely to include from the fifth cervical vertebra to the fifth dorsal vertebra and the lung field on either side. The whole length of the first dorsal ribs should be clearly shown.

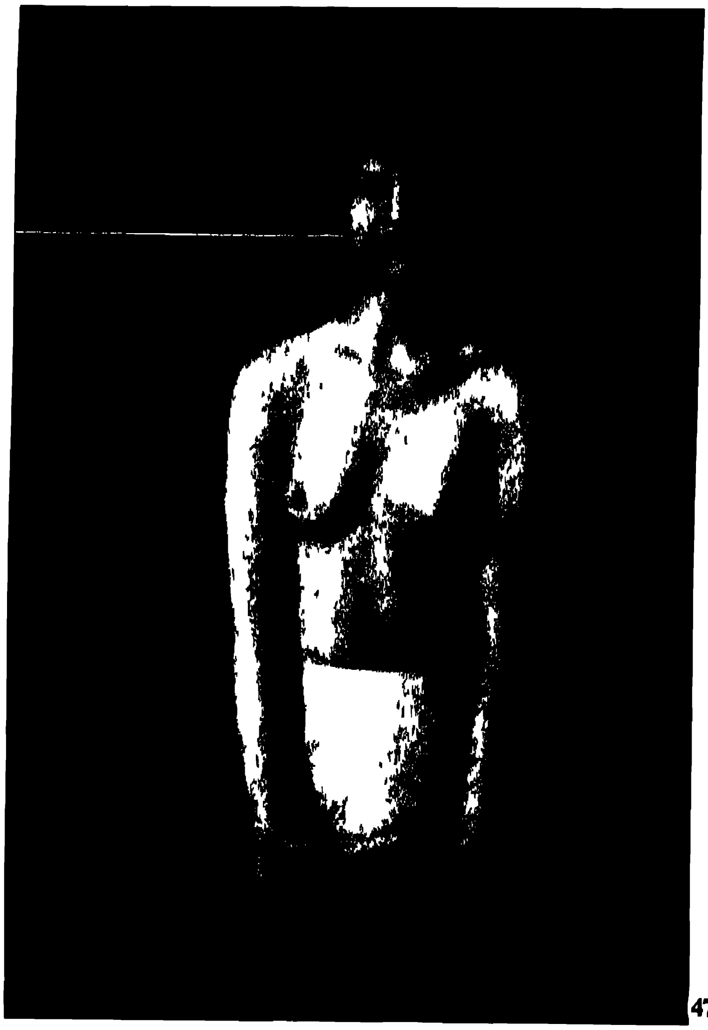
CENTRE at the level of the sternal notch, preferably with the tube angled 15 degrees toward the head, as shown by the oblique line in (471), otherwise small rudimentary cervical ribs may be missed.

(471, 472)

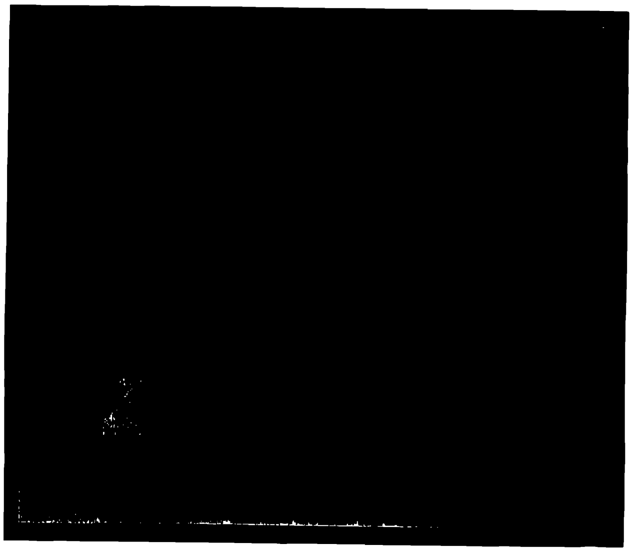
The exposure is made on inspiration, as for lung technique, but at a higher kilovoltage to ensure the spine-rib articulations being shown.

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	20	12	36"	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in.



473



474

Bones of the Thorax: Cervical Ribs

LATERAL

The patient is placed in the erect position, with the shoulder of the affected side in contact with the film support. The shoulders are depressed and the neck stretched upward to allow the seventh cervical region to be projected clear of the trunk. The head is immobilised in the erect position, and the 10 inch by 8 inch film is placed longitudinally to the spine to include from the fifth cervical to the fifth dorsal vertebra. Lateral cervical technique is described in greater detail on pages 120 and 121.

CENTRE to the third cervical vertebra.

(473, 474)

Lateral radiographs are not always included in the examination for cervical ribs, but the advantage of this view is seen in radiograph (474). An oblique view may sometimes be found desirable.

EXPOSURE FACTORS						
	mA. Secs. Ilford Developers					
kVp.	X-ray	Blue Label	Distance	Film	Screens Ilford	Grid
70	25	15	60"	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in.

Costal Cartilages

Occasionally the costal cartilages are calcified to a varying extent, and may be demonstrated radiographically. In the majority of subjects, however, these cartilages are invisible, and a radiographic demonstration of an injury including the cartilage at the costo-chondral junction is not often possible. Small isolated areas of calcification sometimes occur and may be confusing in the examination of the abdominal or thoracic viscera.

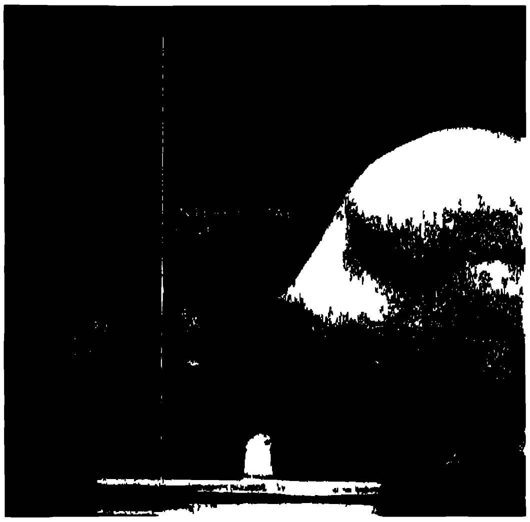
Patients are frequently sent for radiographic examination of the lower anterior rib region when it is quite obvious, both from the details on the request form and from the patient, that the region of the costal cartilages is required and that the rib field is not involved.

SECTION 9

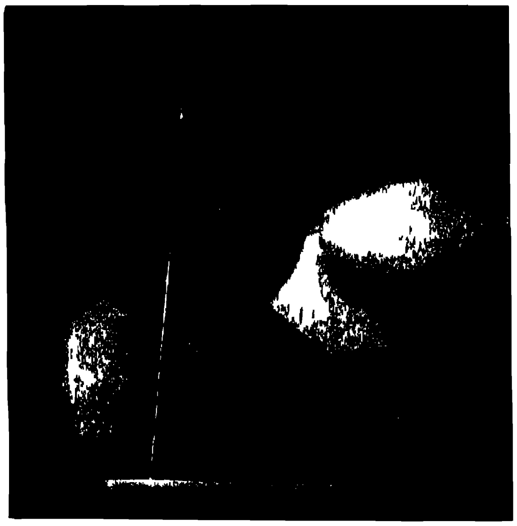
Skull

475

476



477



478

SECTION 9

SKULL: GENERAL

For the purposes of examination the skull is regarded as possessing two regions, the *cranial* and the *facial*, their anatomical peculiarities being so different as to demand individual treatment.

The bony cranium enclosing the brain may be likened to a closed box having sides, top, and base. The last is a most complex surface, presenting special problems to the radiographer, and is discussed also in Section 14. The facial portion of the skull consists of numerous small bones enclosing many air cavities, which latter are dealt with in Section 12.

Appreciation of the anatomical formation of the skull is perhaps more important than that of any other part of the skeleton. Reference to the dry skull is often necessary, and no X-ray department can be considered to be adequately equipped unless a good specimen skull is available both for anatomical reference and for trial exposures.

MEDIAN PLANE

The *median plane*, or line, divides the head vertically, from the front backward, into two symmetrical halves, and when the head is positioned correctly is parallel to the film for the lateral view **(475)** and at right angles to the film for the antero-posterior and postero-anterior views **(476)**.

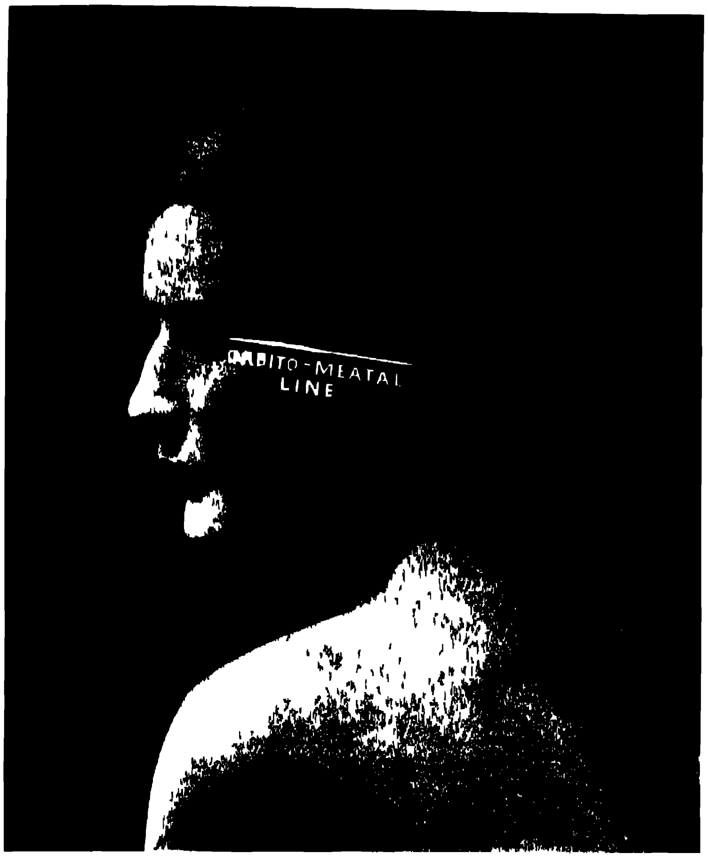
INTERORBITAL LINE

An imaginary line drawn between the right and left pupils is known as the interpupillary, or *interorbital*, line **(477)**.

When the patient is placed in such a position that the interorbital line is at right angles to the film it is an indication that the head is correctly adjusted to the true lateral position from vertex to chin **(477)**. This line also serves as a guide to the tube angulation required when it is not possible otherwise to position the patient correctly in relation to the film. Thus, when the axial ray is projected parallel to the interorbital line and at right angles to the median plane **(484)** a true lateral view will result under conditions such as shown in **(478)**.

ORBITO-MEATAL LINE (Radiographic base line)

The *orbito-meatal line* is an imaginary line drawn between the outer canthus of the eye and the external auditory meatus, and is known as the *radiographic base line*, being referred to by radiographers as the *base line* **(479)**: it is used to indicate the angle at which the head should be adjusted in relation to the film. The terms "nose-chin" and "nose-forehead" are approximate only, since facial contours vary with length of nose and prominence, or the



479

480

481

reverse, of forehead and chin, and without the base line angle check these descriptions of the two positions are very indefinite.

It should be noted, however, that only in very exaggerated types is the base line greatly displaced from being at right angles to the couch when the patient is placed with the nose and forehead toward the film.

The skull may be examined with the subject in either the erect or the horizontal position, but as the condition of patients for this examination usually necessitates the latter, principally horizontal technique is described and illustrated.

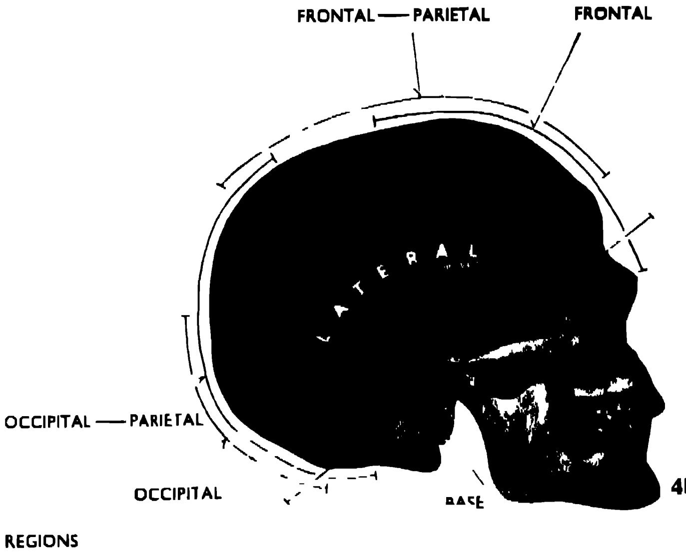
The injured person, generally suffering from shock, is brought to the X-ray department on the stretcher trolley, and the films are exposed as quickly as possible with the minimum of discomfort to the patient. Additional injuries to the extremities or trunk may require that the entire examination be carried out with the patient in the supine position, the ward mobile unit being utilised as for ward technique.

Apart from injury the skull demands examination for many pathological conditions, and each subject should be treated individually. Additional stereoscopic films may be taken from any aspect according to the requirements of the radiologist.

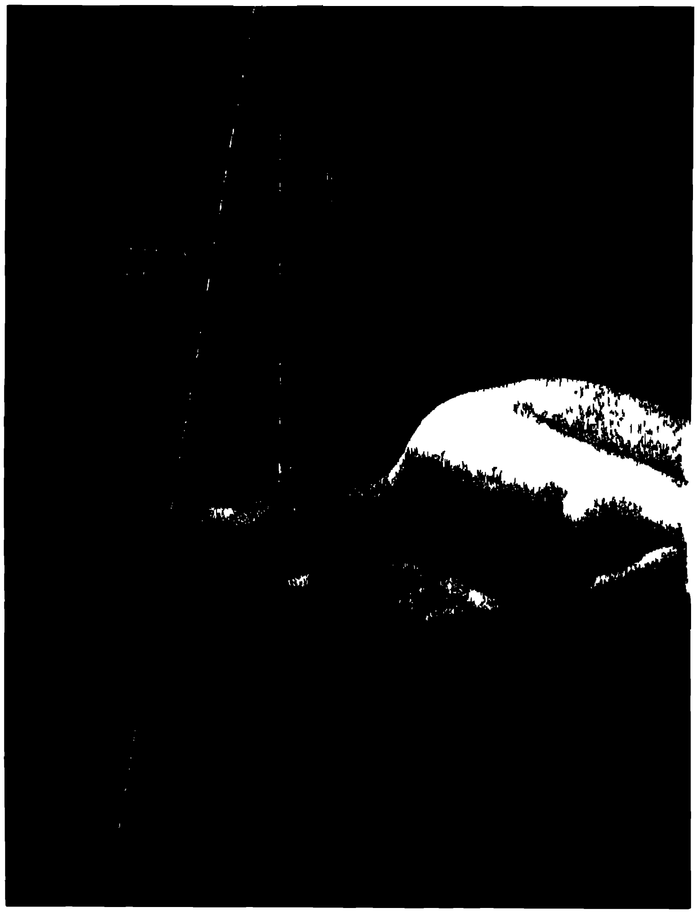
Prior to the examination all opacities should be removed from the head and neck: these may include hair-pins and clips, ear rings, artificial dentures, neck ornaments, collar studs, and sometimes a glass eye.

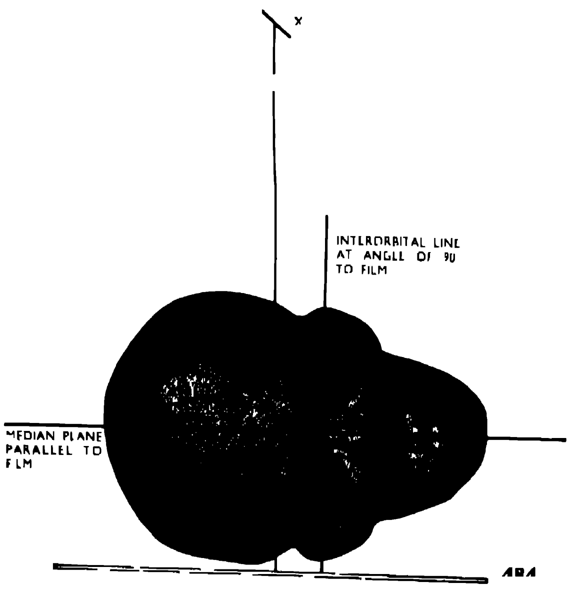
For the general views it is necessary to use films of suitable size to include the whole of the skull. Intensifying screens are essential, and the Potter-Bucky diaphragm has long been established as a necessity in skull work, although it is possible to obtain satisfactory films without a grid. Skull films taken in the ward, however, are not on the whole, a credit to the radiographer, but the introduction of the stationary grid has done much toward improving ward technique. The use of a localising cone greatly improves definition. The anode-film distance applied depends on conditions available in the department and according to whether both aspects are required to be in focus, as in teleradiography, or only the aspect nearest the film, as in 25 inch to 30 inch distance technique. Two films showing the lateral view of the same subject taken at 24 inches(**480**) and 48 inches (**481**), respectively, demonstrate the effect of distance on enlargement distortion and definition.

The head is immobilised by the use of non-opaque pads and loosely-filled sandbags, the head clamp, the compressor band, or by a broad band having weighted ends. To avoid obscuring the precise position of the patient in the illustrations, immobilisation accessories are not shown.



482


483



484

Skull: General

POSITIONING TERMINOLOGY

The frequently varied description of a limited number of positions of the head is so unsatisfactory as to cause much doubt as to the particular view intended unless the name of the originator of the position is applied and as such is known to the individual worker. This name terminology, however, also leads to much confusion. The various positions are, therefore, named according to the direction of the X-ray beam through the head, namely, occipito-frontal, fronto-occipital, vertico-mental, mento-vertical, and lateral, when the axial or normal ray is at right angles to the film. When the tube is otherwise angled in relation to the film the particular angle prefixes the position of the head—such as 10 degrees occipito-frontal.

Cranium

In order to cover the sides, front, top, back and base of the cranial box completely it is necessary to make six or seven separate exposures to show the lateral, frontal, frontal-parietal, occipital-parietal, occipital and base regions **(482)**. Obviously, all these views will not be included for each examination of the cranium; three general views are usually sufficient—lateral, occipito-frontal and 30 degrees fronto-occipital—the remaining views being taken in special circumstances as required.

In the text the cranial positions are not given in order of importance, but in *anatomical sequence*, as shown in the dry skull **(482)**.

LATERAL (1)

The patient is placed in the prone position, with the head turned so that the affected side is toward the film, the opposite shoulder being raised and supported on sand-bags, with the elbow flexed and the arm resting on the side of the couch to steady the head and trunk in position. The opposite arm is extended beside the trunk, with the hand palm upward. The head is adjusted to the true lateral position with the orbits one above the other at right-angles to the film and with the median plane parallel to the film. A non-opaque pad or cork placed under the jaw steadies the head in position, or the patient may support the chin on the hand, as shown in the illustration **(483)**. In thick-set subjects it is not always possible to adjust the head to the true lateral position, in which case it is necessary to angle the tube until the normal ray is parallel to the interorbital line, the position of the film being adjusted accordingly.

485

486

487

Skull: Cranium

LATERAL (1)—(*continued*)

Illustration **(484)** shows the correct position of the skull in relation to the X-ray tube and film.

Illustration **(485)** shows the result of two films being exposed simultaneously, one between screens to show bone structures and the other without screens to show soft tissues, superimposition of the one on the other demonstrating the relationship between soft tissue contours and inner bone structures.

CENTRE midway between the glabella and the occipital protuberance **(485)**, the cassette being placed transversely and displaced toward the vertex.

(483, 484, 485, 486)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	80	48	30	Ilford	Tungstate	Potter-Bucky
60	200	120	48″	Ilford	Tungstate	Potter-Bucky
*60	30	18	30″	Ilford	Tungstate	
*70	40	25	30″	Ilford	Tungstate	Stationary

Cone to allow for film displacement size of film, 12 × 10 in

* Ward mobile unit.

The resulting radiograph shows the cranial and facial bones overlapping from side to side; and this particular radiograph **(486)**, taken at an anode-film distance of 48 inches, is so perfectly lateral that the teeth exactly overshadow from right to left of the mandible, giving the appearance of a dry skull, the illusion in this instance being aided by perfectly matching teeth.

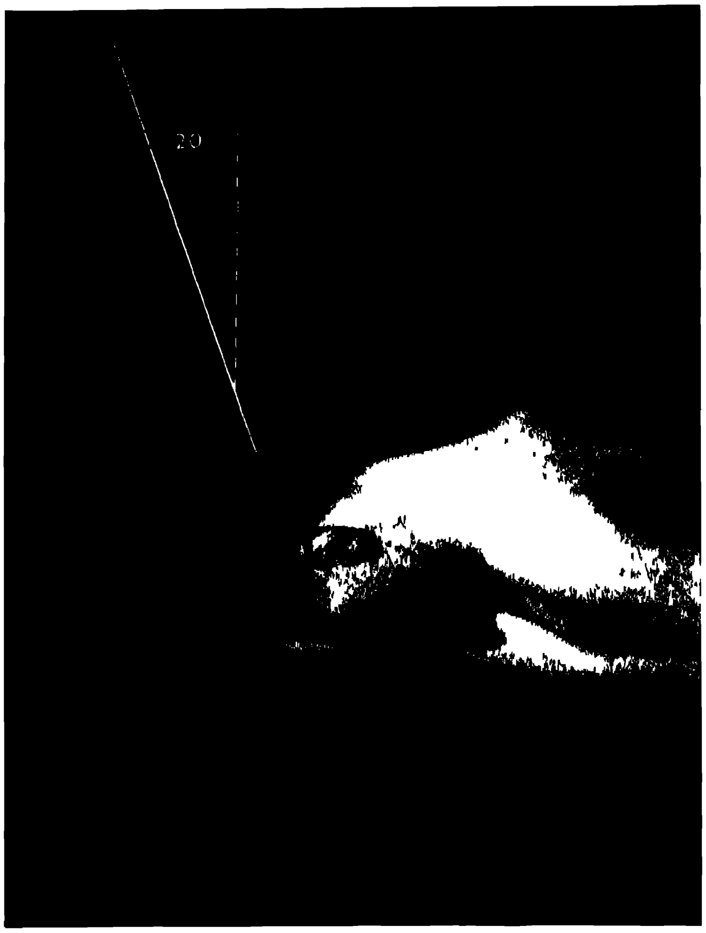
STRETCHER PATIENTS
LATERAL (2)

When the patient is supine in bed or on the casualty stretcher trolley, the head should be raised on a thick, non-opaque pad and the film placed vertically against the lateral aspect of the head, with its lower edge on the stretcher, the X-ray beam being projected horizontally toward the head and at right angles to the film.

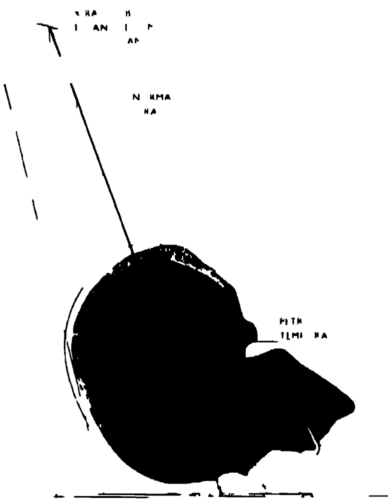
CENTRE midway between the glabella and the occipital protuberance, the film being displaced toward the cranium. **(487, 488)**

The stationary grid was used for radiograph **(488)**.

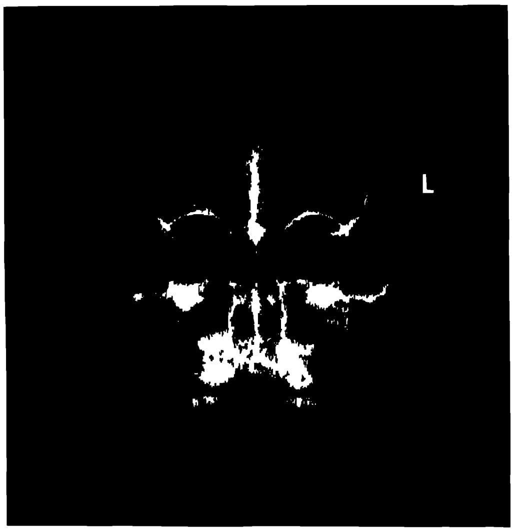
Skull: Cranium



489



490



491

REGION—FRONTAL
POSITION—20 DEGREES OCCIPITO-FRONTAL

In this view the entire frontal bone is included without undue distortion, but this position should not be confused with the view shown on the opposite page **(492)**, nor used to replace the general view of the facial bones, which will be seen on page 188.

With the patient in the prone position, the head is placed with the nose and forehead toward the film and adjusted so that the base line and the median plane are at right angles to the film. The hands are placed under the chest to assist immobilisation, and the ankles are supported over a sandbag, thus avoiding undue discomfort to the patient.

CENTRE through the vertex, toward the naso-frontal articulation, with the tube angled 20 degrees toward the feet, the film being placed with its upper border immediately beneath the uppermost margin of the head.

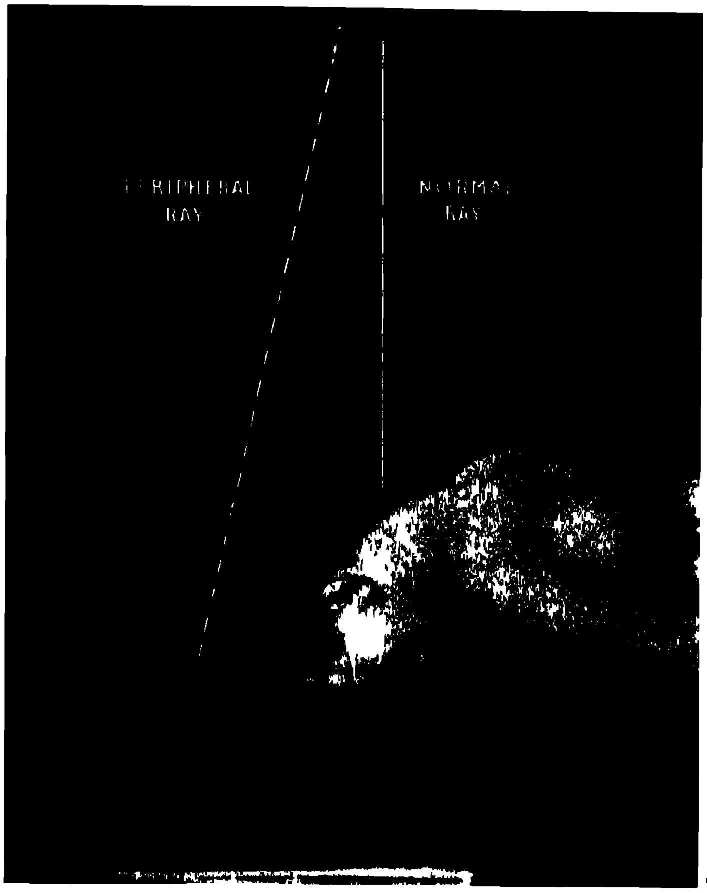
(489, 490, 491)

EXPOSURE FACTORS						
kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	46	28	30″	Ilford	Tungstate	—
70	60	37	30″	Ilford	Tungstate	Stationary
70	230	140	48″	Ilford	Tungstate	Potter-Bucky

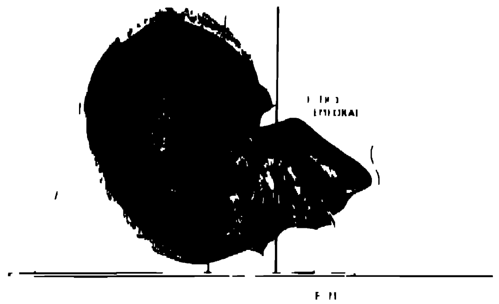
Cone to allow for film displacement: size of film, 12 × 10 in.

The tube angulation and high centring serve to project the dense petrous temporals below the orbits, as shown in the mid-line section of the dry skull **(490)**. This illustration should be compared with **(493)**.

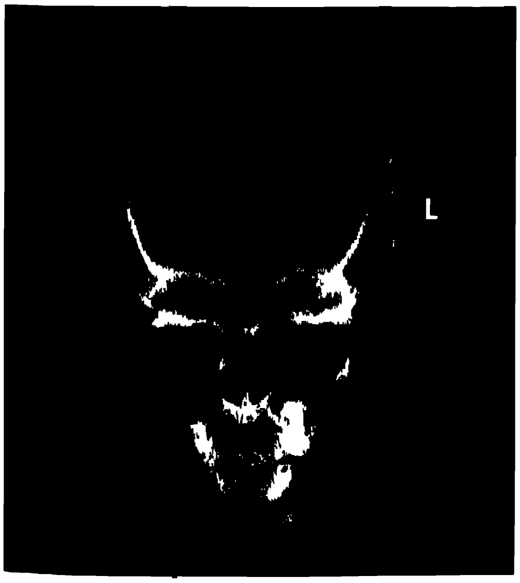
Comparison should also be made of the centring shown in **(489)** and **(492)** and of the radiographs **(491)** and **(494)**.



492



493



494

Skull: Cranium

REGION—FRONTAL PARIETAL (1) POSITION—OCCIPITO-FRONTAL

This is one of the general routine views of the skull, and includes the naso-frontal to the mid-parietal region (482, 494). The placing of the head to obtain this view is generally referred to as the "nose-forehead" position, but more particularly as the "occipito-frontal" position, in which latter term is indicated the relationship between the base line and film.

With the patient in the prone position, the head is adjusted so that the nose and forehead are in contact with the couch and with the base line at right angles to the film. The hands are clasped under the chest to assist immobilisation by eliminating strain and discomfort such as occurs in this position when the arms are beside the trunk. A sandbag under the ankles also adds to the patient's comfort.

CENTRE to a mid-line point 2 inches below the occipital protuberance. The cassette is placed lengthwise to the couch and displaced toward the head, the upper border of the film being 2 inches beyond the highest point of the head in this position.

(492, 493, 494)

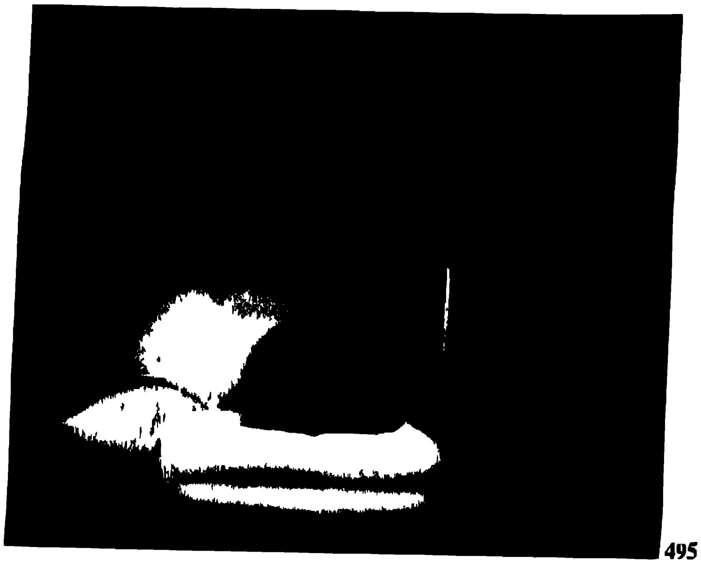
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	100	60	30″	Ilford	Tungstate	Potter-Bucky
65	264	160	48″	Ilford	Tungstate	Potter-Bucky

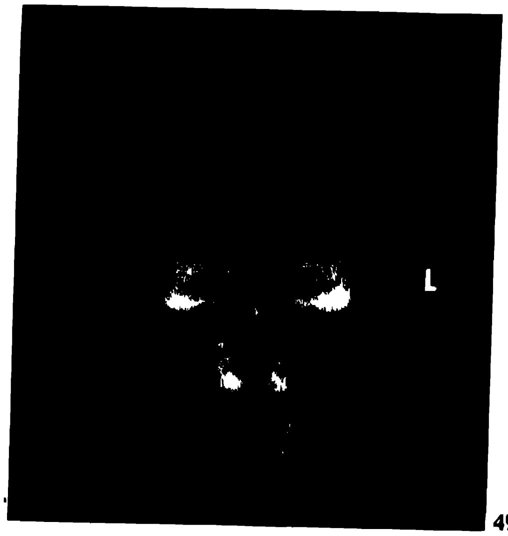
Cone to allow for film displacement: size of film, 12 × 10 in.

Illustration (493) shows the relationship between soft and bone structures, X-ray tube and film, and indicates the method of projecting the maximum surface of the cranium clear of dense areas of bone, particularly of the petrous temporals. In this instance the petrous temporals are projected to overshadow the orbits.

Skull: Cranium



495



496

STRETCHER PATIENTS
REGION—FRONTAL PARIETAL (2)
POSITION—OCCIPITO-FRONTAL

When examining patients on the casualty stretcher or in bed, and when conditions are such that general movement of the trunk and limbs is not permissible, the head should be raised on a non-opaque pad and turned through a right angle so that the nose and forehead may make contact with the film, which is placed vertically. The shoulder remote from the film is raised on sandbags to allow the head to be maintained comfortably in position.

CENTRE from the horizontal position to the nape of the neck, and at right angles to the film.

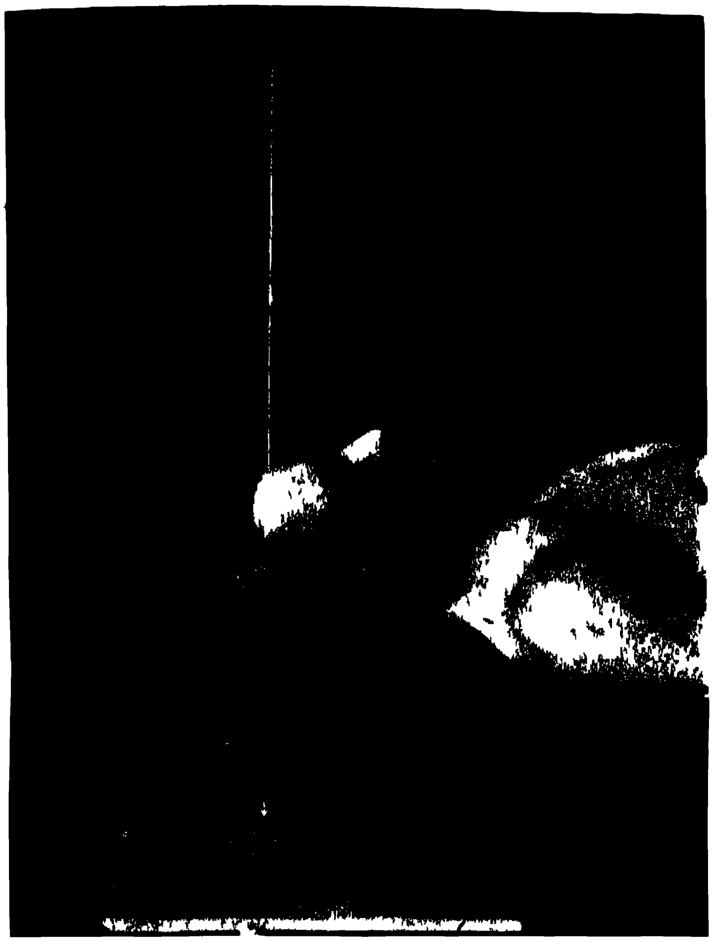
(495, 496)

EXPOSURE FACTORS

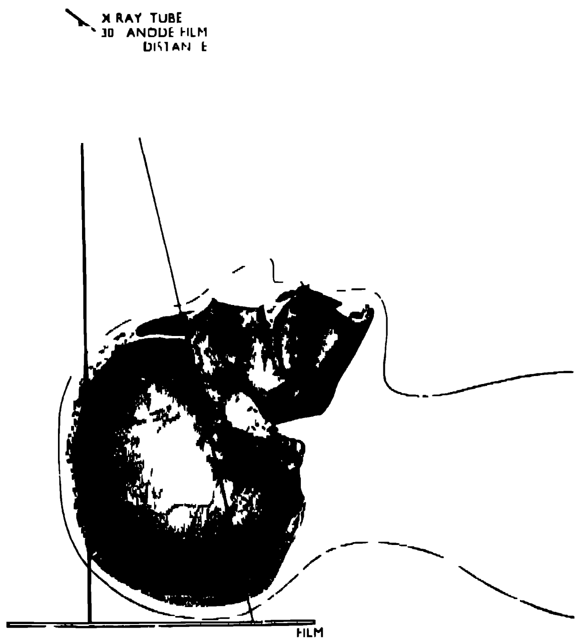
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
*60	60	36	30"	Ilford	Tungstate	—
*70	75	45	30"	Ilford	Tungstate	Stationary
—						

Cone to allow for film displacement size of film, 12 × 10 in.
* Ward mobile unit.

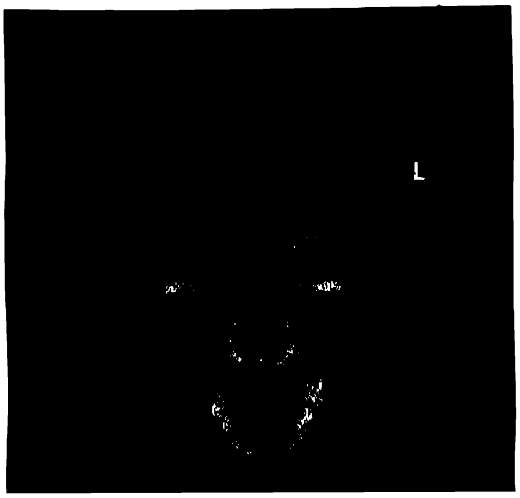
NOTE—Satisfactory films are obtained under these conditions, especially when the stationary grid is employed, as in (496). It is essential to raise the head to allow the cassette to be placed low enough to include the side of the head nearest to the couch. A firm wool cushion of suitable dimensions should be kept especially for this purpose.



497



498



Skull: Cranium

STRETCHER PATIENTS
REGION—FRONTAL PARIETAL (3)
POSITION—FRONTO-OCCIPITAL

With seriously injured subjects, where the head cannot be turned to one side as in (495), it may be necessary to reverse the occipito-frontal position, in which case, *with the patient supine*, the head is raised on a small non-opaque pad. This allows the head to be flexed slightly forward with the chin toward the chest, thus preventing undue strain on the neck and greatly assisting immobilisation. Sandbags on either side, but separated from the head by non-opaque pads, will complete immobilisation.

CENTRE, with the tube straight, over the vertex of the skull.

(497, 498, 499)

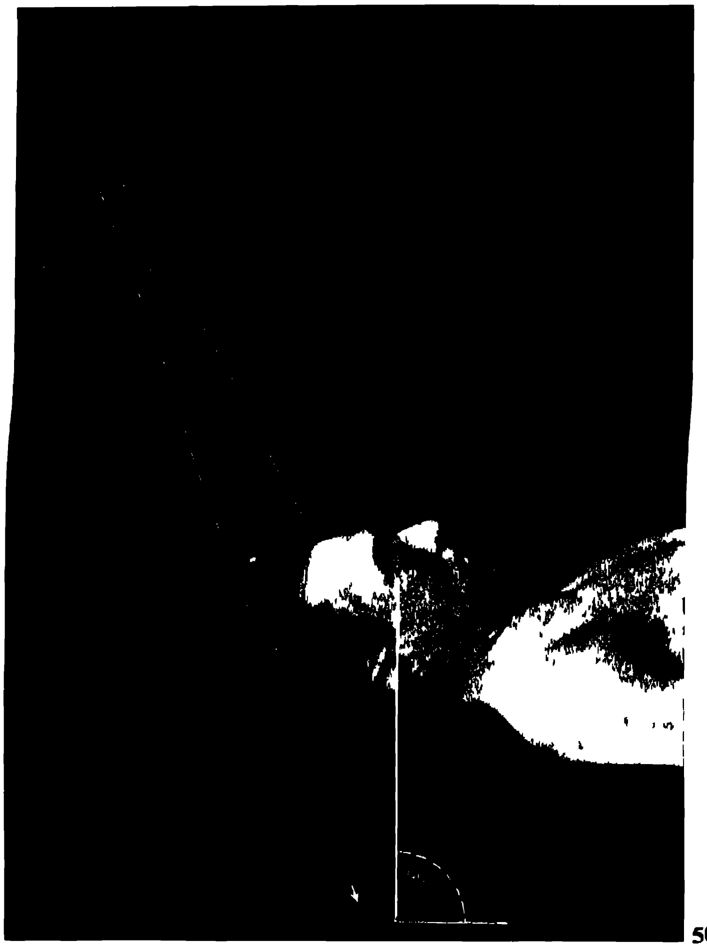
EXPOSURE FACTORS						
	mA Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*60	60	36	30″	Ilford	Tungstate	—
*70	75	45	30″	Ilford	Tungstate	Stationary
65	264	160	48″	Ilford	Tungstate	Potter-Bucky

Cone to allow for tube displacement: size of film, 12 × 10 in.
* Ward mobile unit.

The high centring over the vertex, which is the reverse of the occipito-frontal centring position (492), serves to project the facial bones and the petrous temporals clear of the cranial bones, as shown in the mid-line section of the dry skull (498). Comparison should be made of radiographs (499) and (494).

NOTE—This type of patient is sometimes lifted on the canvas stretcher cloth direct from the ambulance to the X-ray couch; in these circumstances the Potter-Bucky diaphragm is employed, as shown in (497).

Skull: Cranium



500

REGION—OCCIPITAL PARIETAL (1)
POSITION—30 DEGREES FRONTO-OCCIPITAL

This view of the occipital bone includes part of the base and vertex of the skull, from the foramen magnum to the mid-parietal region.

The patient is placed in the supine position, with the chin well down on the chest so that the base line is approximately at right angles to the film. To avoid discomfort a small non-opaque pad should be placed under the patient's head. A larger pad may be used to raise the head into a more satisfactory position when it is inclined to tilt backward, as will occur in the thick-set type of subject. With such patients an increased anode-film distance should be employed to avoid enlargement distortion.

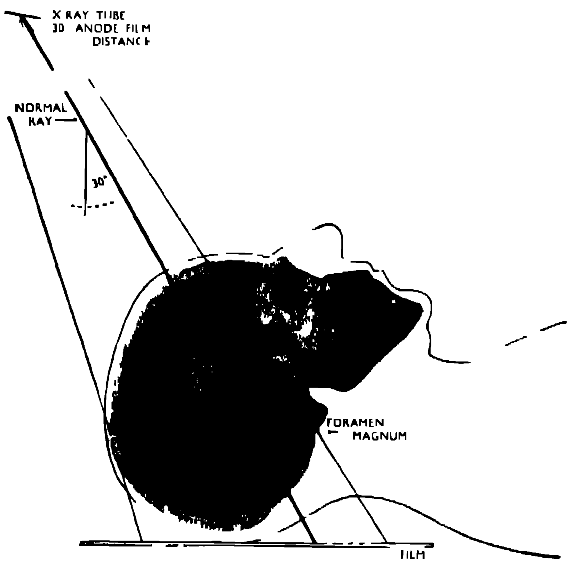
CENTRE obliquely through the frontal bone, toward the feet, with the tube angled 30 degrees to the *base line*, which, under ideal circumstances, should be at right angles to the film, as in (500) and (501). This tube angle to the *base* line may vary from 30 degrees to 45 degrees in relation to the *vertical*, this depending entirely upon the adjustment of the head on the couch. The cassette is placed lengthwise to the couch, the upper border of the film being immediately beneath the highest point of the head in this position.

Illustration (501), showing a mid-line section of the skull, indicates the relative positions of the various bone structures, X-ray tube and film.

(500, 501, 502)

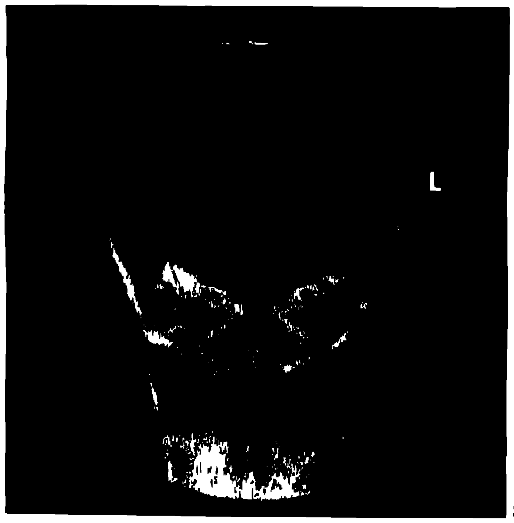
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	92	56	30"	Ilford	Tungstate	Potter-Bucky
65	200	120	44"	Ilford	Tungstate	Potter-Bucky

Cone to allow for film displacement: size of film, 12 × 10 in.

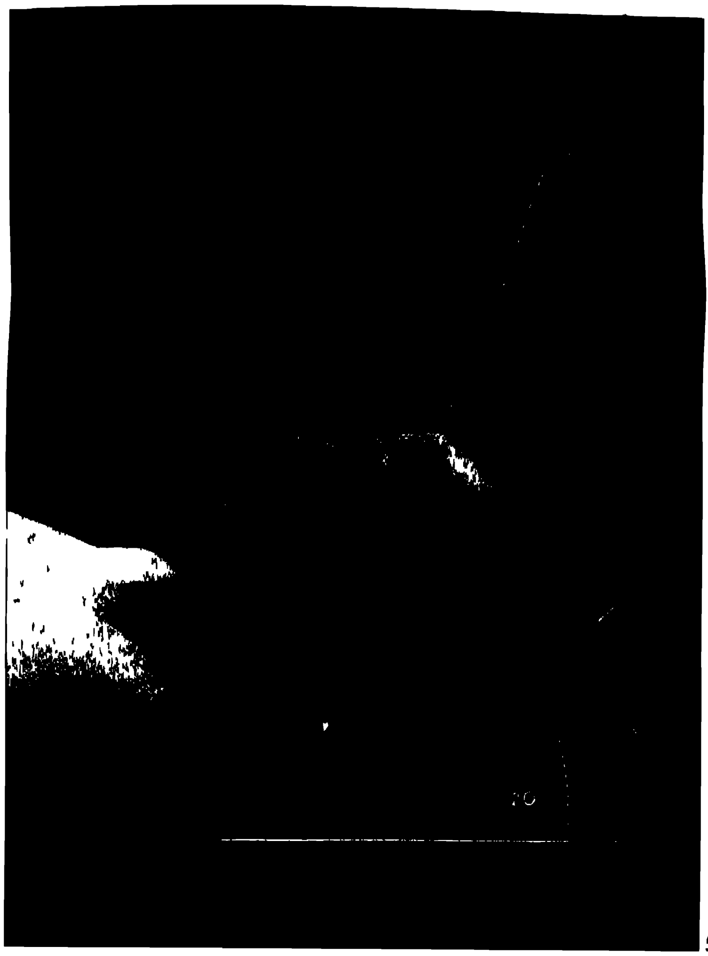


501

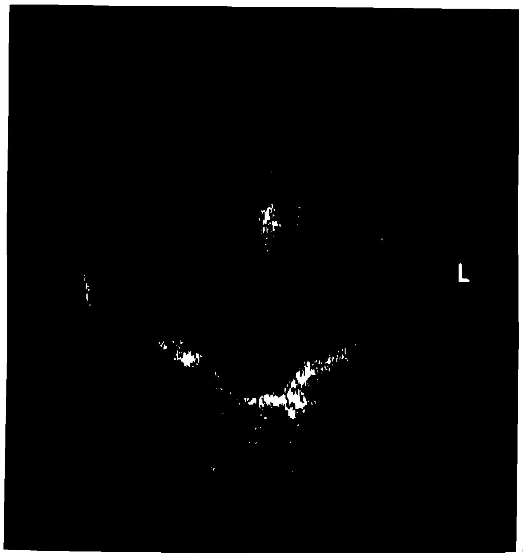
NOTE—This position gives an excellent view of the occipital bone and structures adjacent to the foramen magnum, and also of the post-parietal region (502).



502



503



504

Skull: Cranium

REGION—OCCIPITAL PARIETAL (2) POSITION—20 DEGREES FRONTO-OCCIPITAL, WITH 20 DEGREES ANGLE BOARD

The thick-set subject is difficult to adjust in position (500), as the head falls backward on to the couch at an awkward angle for taking this view and in a very uncomfortable position for the patient.

As described on the previous page, a thick non-opaque pad may be placed under the head and a compensating increased anode-film distance employed, but there are circumstances in which this method fails to produce a satisfactory result.

As an alternative the head, with the cassette in contact, may be raised on a 20 degrees angle board, the stationary grid being also used when available. The general plane of the face is parallel to the film. A sandbag should be placed against the open end of the angle board to prevent it from slipping away from the patient's head.

CENTRE through the vertex and toward the foramen magnum, with the tube angled 20 degrees toward the feet.

(503, 504)

EXPOSURE FACTORS

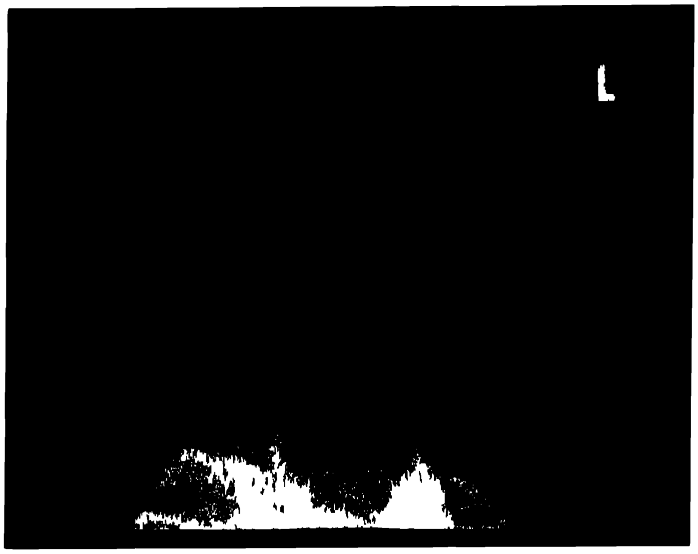
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*60	50	30	30"	Ilford	Tungstate	—
*70	68	40	30"	Ilford	Tungstate	Stationary

Cone to allow for film displacement: size of film, 10 × 8 in. or 12 × 10 in.

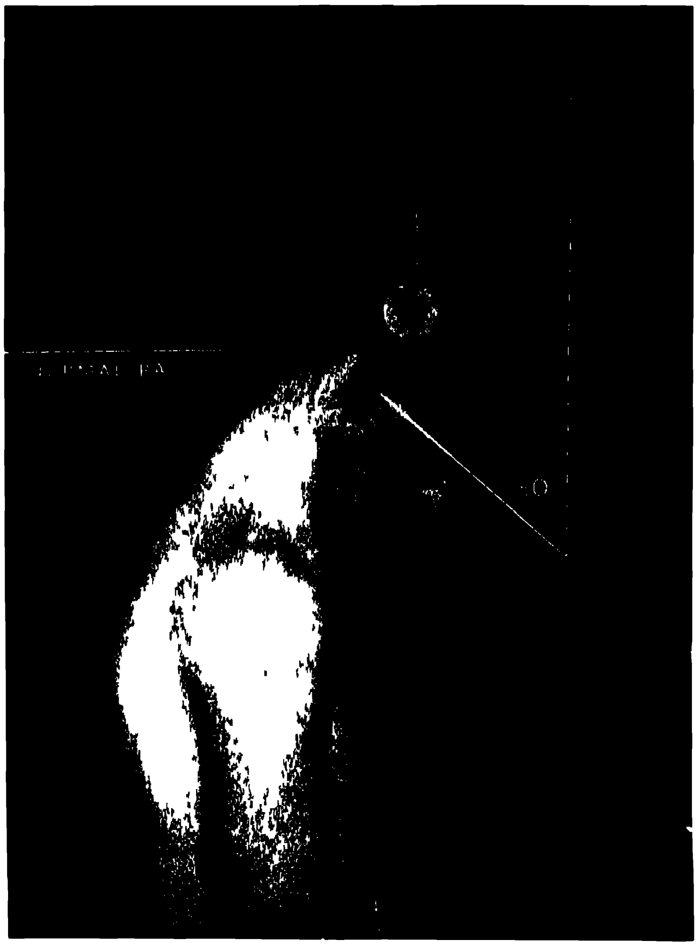
* Ward mobile unit.

NOTE—A satisfactory view is obtained by this method without discomfort to the patient. In the absence of an angle board a sandbag may be used to support the film and grid at the appropriate angle.

505



506



507

Skull: Cranium

REGION—OCCIPITAL
POSITION—OCCIPITO-VERTICAL

This position, showing the occipital bone **(482)**, is not as frequently employed as the positions shown on the previous two pages **(500, 503)**.

The patient is in the prone position, with the trunk raised on blocks or pillows so that the neck can be flexed to bring the vertex of the skull into contact with the X-ray couch. The anode-film distance is increased to 48 inches to eliminate distortion due to subject-film displacement.

CENTRE over the occipital protuberance.

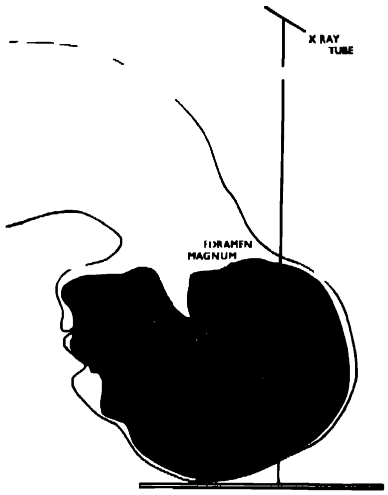
(505, 506, 507, 508)

EXPOSURE FACTORS						
kVp.	mA Secs Ilford Developers X-ray	mA Secs Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	200	120	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in or 12 × 10 in.

It should be noted that the mastoid air cells are shown on either side and at the level of the foramen magnum **(506)**.

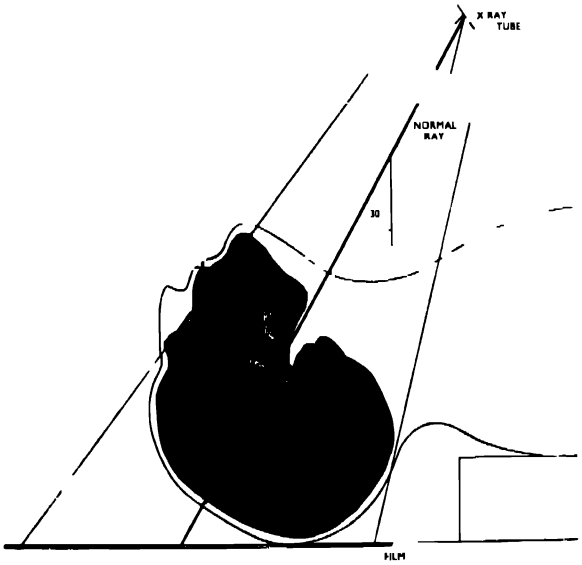
The erect position **(507)** is equally satisfactory, and, when the patient's condition is suitable, is more easily sustained than the horizontal position.



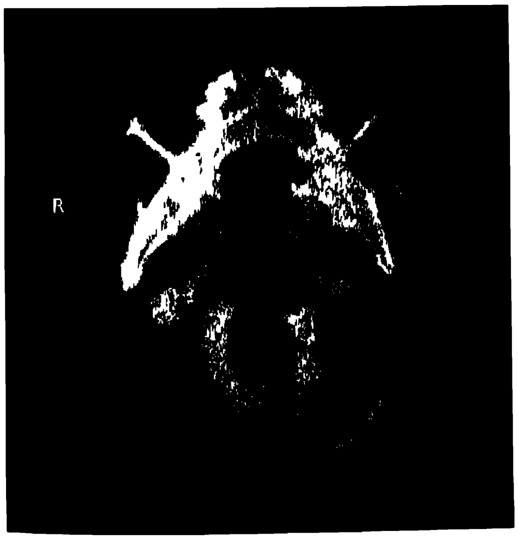
508

Illustration **(508)** shows the relationship between occipital bone, X-ray tube and film.

509



510



511

Skull: Cranium

REGION—BASE
POSITION—MENTO-VERTICAL

This position gives a plan of the cranium **(482, 511)**.

With the patient supine, the shoulders are raised on sandbags and the head allowed to fall backward until the vertex of the skull is in contact with the couch. The possible degree of extension of the neck for this position varies with each patient, from the short-necked to the long-necked type, the ideal position of the head being obtained when the base line is parallel to the film. The erect position is sometimes more acceptable to the patient.

CENTRE between the angles of the jaw, with the axial ray parallel to the mid-line of the face. Obviously, the necessary degree of tube angulation in relation to the film will depend on the position of the patient's head. The cassette is placed lengthwise, with the lower border of the film immediately beneath the occipital protuberance.

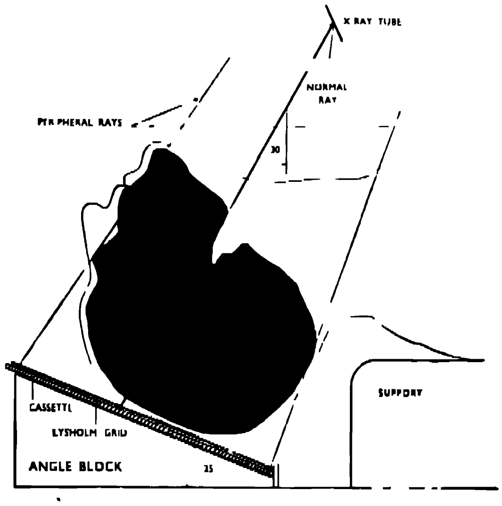
(509, 510, 511)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	76	46	36″	Ilford	Tungstate	Station-ary
80	200	120	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in.

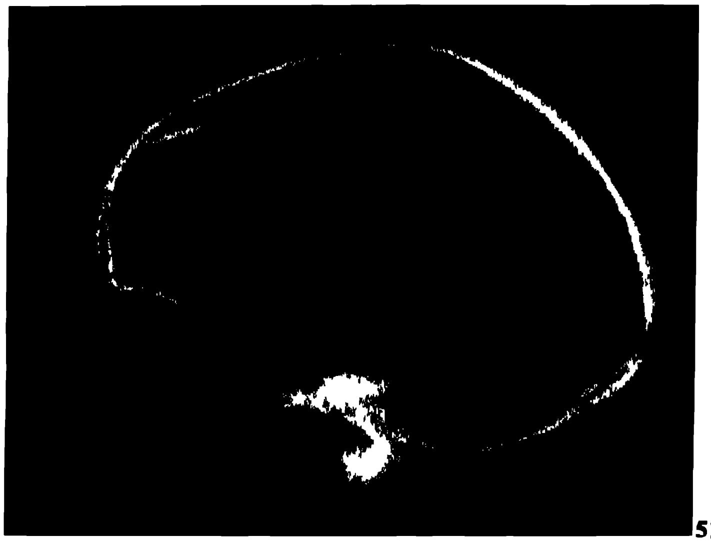
Illustration **(510)** shows the relationship between skull, X-ray tube and film.



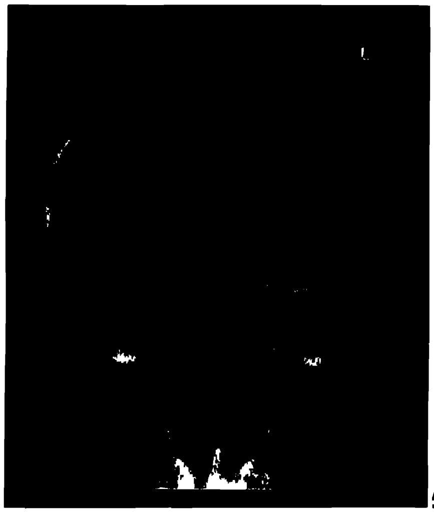
512

With a short-necked subject difficulty will be experienced in obtaining this position, in which type of case the angle board and stationary grid will be of great assistance **(512)**.

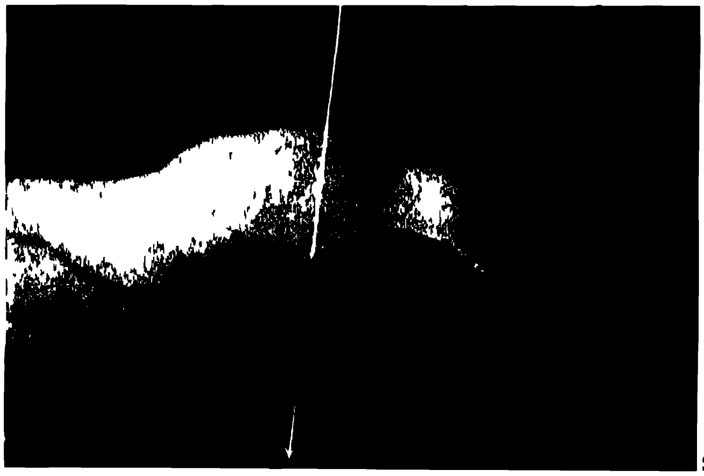
NOTE—A lighter exposure will show some of the facial bones—particularly the zygomatic arch—from an unusual angle.



513



514



515

516

Skull: Cranium

LOCALISED VIEWS

In pathological conditions two general views are taken, such as (**513**, **514**). These may be followed by other general views, to include stereoscopic films, taken from one or more aspects. Additional knowledge may also be obtained by placing the head so that the abnormal area is in profile (**515**).

CENTRE over the localised area, using a small extension cone.

(**515**, **516**)

The radiograph (**516**) shows a typical example of localised technique, which may be applied to any area of the skull. The general routine views (**513**, **514**) are of the same subject.

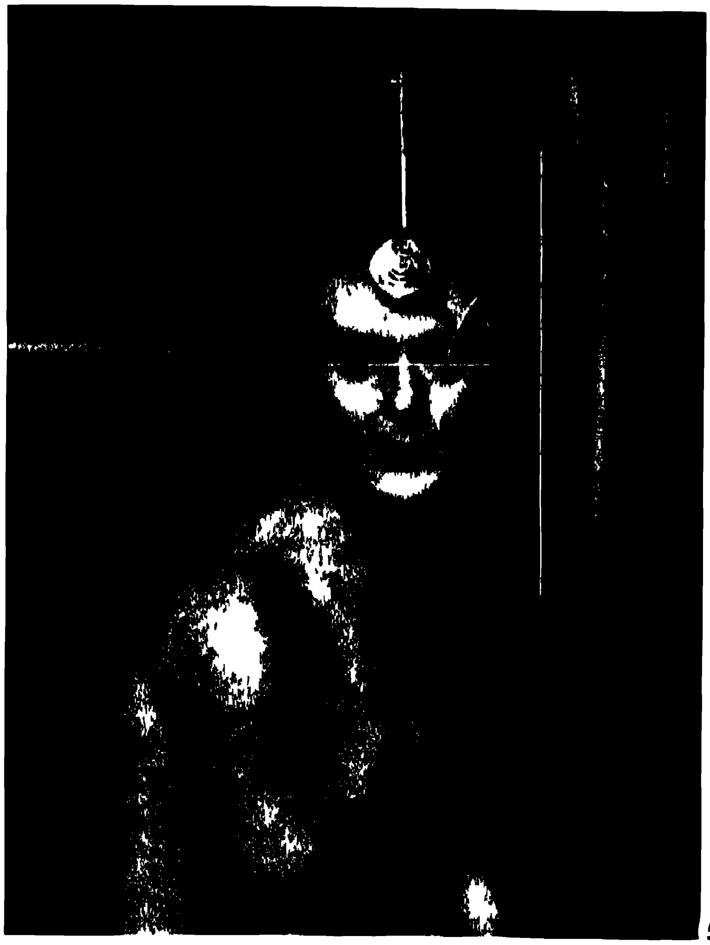
NOTE—The exposure factors should be adjusted to suit the localised area examined, a reduction of from 5 kilovolts to 10 kilovolts being usually made. Further useful information may be gained regarding the soft structures by exposing two films simultaneously, one between intensifying screens and one without screens.

Pituitary Fossa (Sella turcica)

On referring to the horizontal section of the dry skull (**520**), it will be seen that the pituitary fossa, with its anterior and posterior clinoid processes, is approximately in the middle of the floor of the cranium. It appears as a shallow depression, and contains the pituitary body.

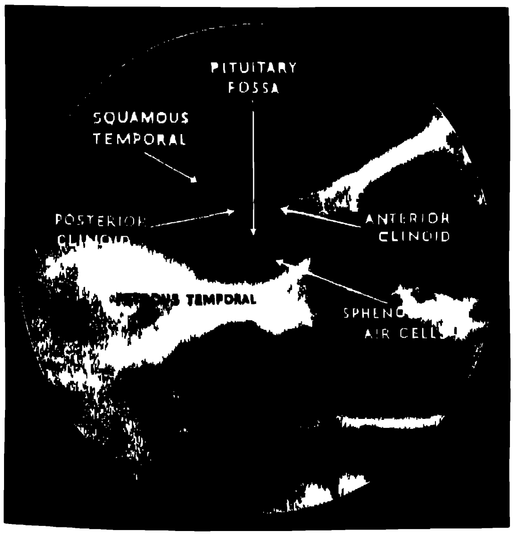
Lateral projections, usually stereoscopic, are most commonly made; and in addition exposures may be made from antero-posterior or postero-anterior aspects, the fossa being projected to overshadow the foramen magnum or the frontal bone, as the case may be.

It is essential that in any repeat exposures which may become necessary the original anode-film distance should be applied: if an adequate anode-film distance is possible teleradiography is to be preferred.



517

518



519

Skull: Cranium—Pituitary Fossa

LATERAL

The fossa can be shown through the squamous portion of the temporal bone from either side equally well, but it is essential that the head be maintained in the true lateral position, with the median plane parallel to the film and the interorbital line at right angles to the film. With the patient erect the head can be kept in position by the use of the head clamp **(517)**, and in the horizontal position by placing a cork or a small sandbag under the jaw and a sandbag against the vertex of the skull. Reference should be made to **(477, 483)**.

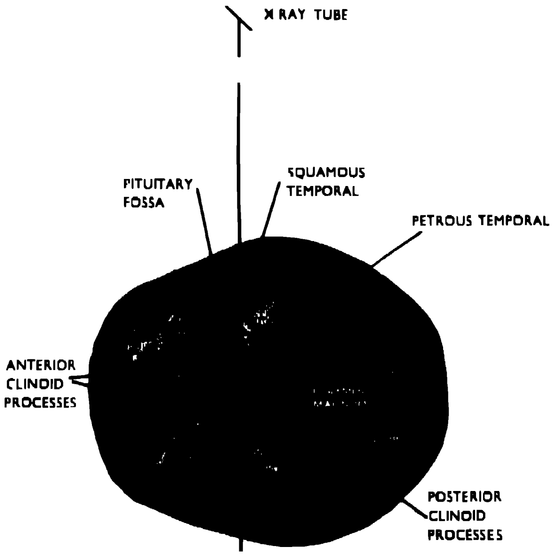
CENTRE one inch in front of and above the external auditory meatus, through the squamous region of the temporal bone. A small localising cone is essential.

(517, 518, 519, 520)

EXPOSURE FACTORS						
	mA Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	26	16	30′	Ilford	Tungstate	—
60	132	80	48	Ilford	Tungstate	Potter-Bucky

Cone to size of film, $8\frac{1}{2} \cdot 6\frac{1}{2}$ in

Radiograph **(518)** was taken with a large localising cone, and shows relative landmarks; and **(519)**, taken with a small cone, gives a larger reproduction of the pituitary area, the important anatomical structures being clearly indicated. This should be compared with the dry skull illustration **(520)**.



520

The illustration of the horizontal section of the dry skull indicates the relationship between skull, X-ray tube and film **(520)**.

Skull: Cranium—Pituitary Fossa

521

Additional views of the pituitary region from other aspects such as postero-anterior and antero-posterior are frequently of value in diagnosis, the aim being to obtain a comparative radiograph taken at a right angle (approximately) to the lateral view. Owing to the situation of the pituitary fossa, with its clinoid processes rising above the level of the dense base structures of the skull, it is necessary to project these shadows to overlay the lesser cranial densities, such as the frontal region from the occipito-frontal aspect and the foramen magnum from the fronto-occipital aspect.

The sphenoidal air cells, situated immediately beneath the pituitary fossa, and showing in the radiograph as two well-marked black areas of unequal size, serve as important landmarks in identifying the position of the pituitary region in the film, especially in views from the occipito-frontal aspect.

POSITION—10 DEGREES OCCIPITO-FRONTAL

The head is placed with the nose and forehead toward the film and with the base line at right angles to the film.

CENTRE 2 inches below the occipital protuberance, with the tube angled 10 degrees toward the head, to allow the axial ray to pass through the glabella.

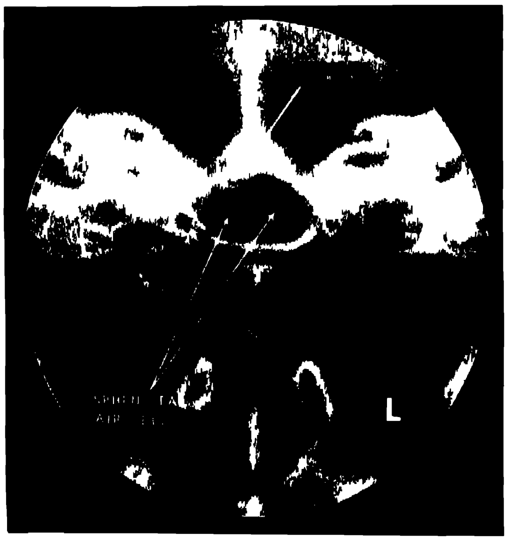
(521, 522, 523)

EXPOSURE FACTORS

kVp	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	132	80	36″	Ilford	Tungstate	Potter-Bucky

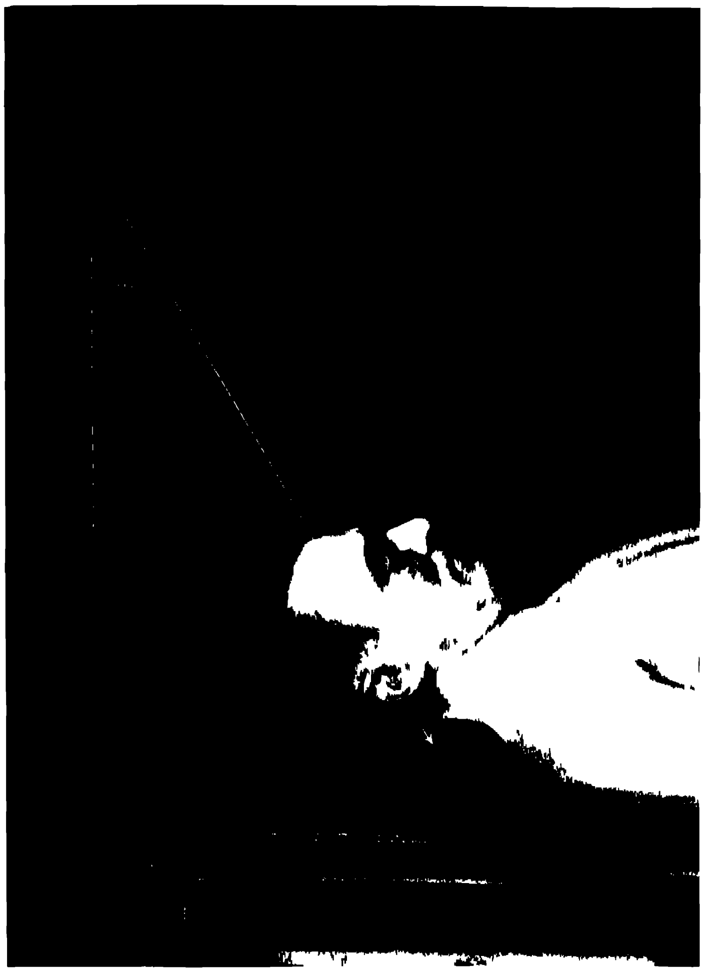
Cone to size of film, 8½ × 6½ in.

522



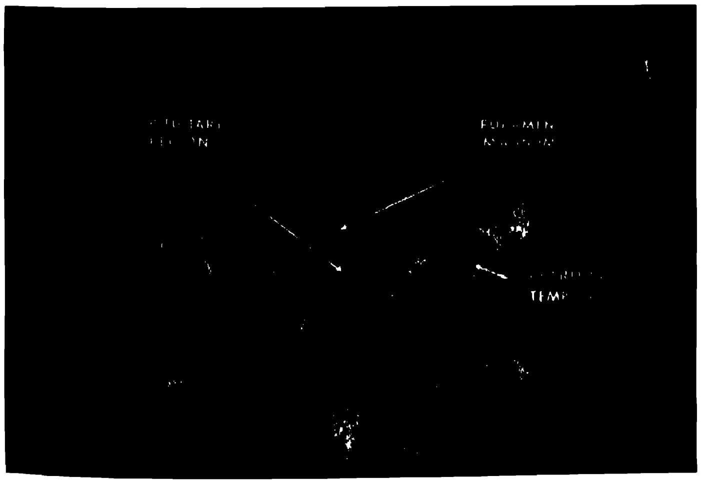
523

The mid-line section of the dry skull is positioned and lined to show the method of projecting the pituitary region to overshadow the frontal bone above the fronto-nasal articulation **(522)**



524

525



526

Skull: Cranium—Pituitary Fossa

POSITION—30 DEGREES FRONTO-OCCIPITAL

The head is placed in the fronto-occipital position, with the chin well down toward the chest so that the base line is at right angles to the film. For further comments on this position reference should be made to 30 degrees fronto-occipital technique given on page 180.

CENTRE through the frontal bone, with the tube angled approximately 30 degrees in relation to the base line and toward the foramen magnum. A small localising cone is essential.

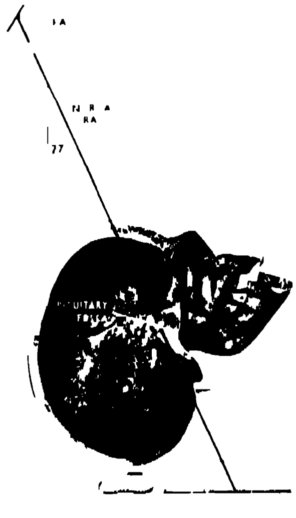
(524, 525, 526, 527)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	200	120	44"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in.

Two radiographs are included—**(525)**, taken with a large localising cone to include general landmarks, and **(526)**, taken with a small aperture to show greater detail.



527

The lined mid-line sectional view of the dry skull shows the method of projection from the antero-posterior aspect, the shadow of the pituitary region appearing either within or just above the foramen magnum **(527)**.

Skull

Facial Bones

Minor injuries to the facial bones are not readily shown radiographically, the films giving a mass of conflicting detail due to the numerous dense, obscuring shadows formed by adjacent regions of the skull. Few workers attempt to take more than one general occipito-mental view, but further information can be obtained by taking stereoscopic pairs, and 30 degrees occipito-mental, lateral, oblique and various localised views, according to the region required.

POSITION—OCCIPITO-MENTAL

This view includes the orbits, the nasal region, the maxillæ, and also the zygomatic bones.

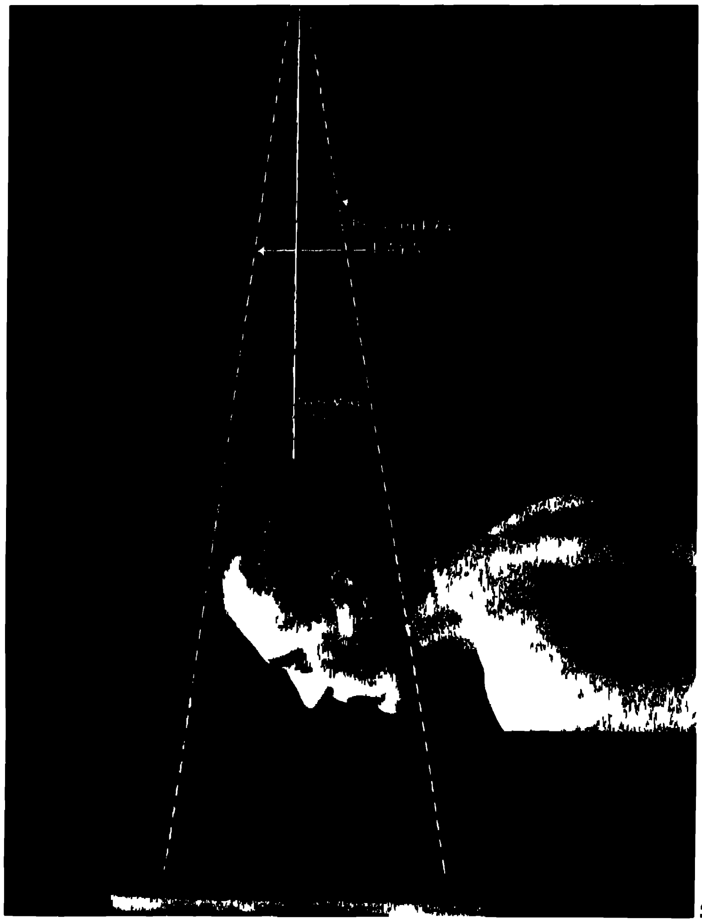
The patient is placed in the prone position, with a sand-bag under the ankles and with the arms beside the trunk. The head is adjusted with the nose and chin toward the film, with the median plane at right angles, and the base line at an angle of approximately 45 degrees, to the film.

CENTRE through the vertex of the skull and toward the fronto-nasal articulation. **(528, 529, 530, 531)**

EXPOSURE FACTORS

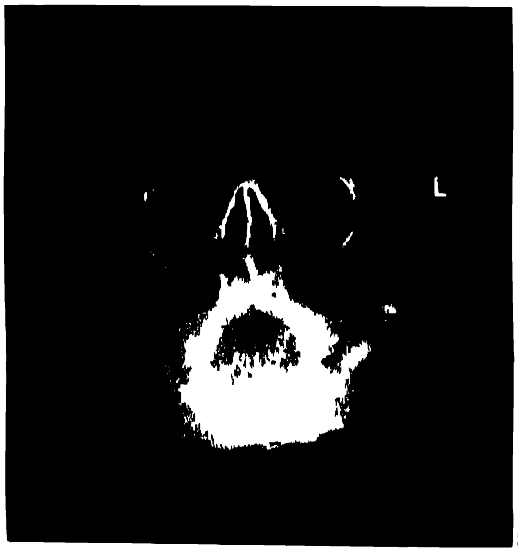
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	40	24	30″	Ilford	Tungstate	—
75	53	32	30″	Ilford	Tungstate	Station-ary
75	200	120	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 8 in. or 12 10 in.



528

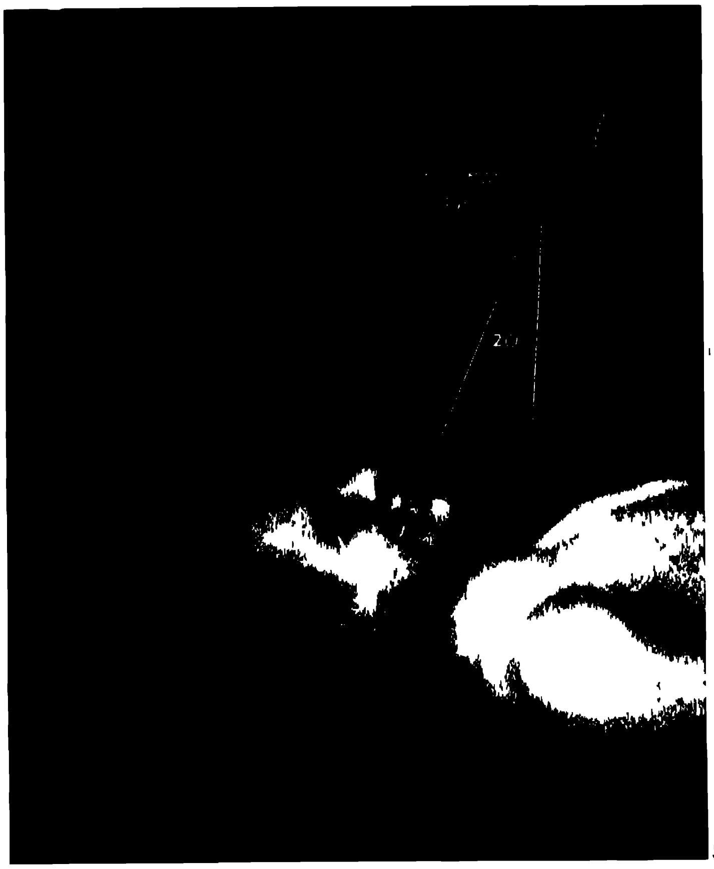
529



530

531

The dry skull is lined to show the method of projecting the denser structures of the skull, such as the petrous temporals, below the lower level of the zygomatic bones. **(531)**



532

Skull: Facial Bones

STRETCHER PATIENTS
POSITION—MENTO-OCCIPITAL 45 DEGREES BASE LINE

Serious injury to the facial bones, or additional injuries to trunk and limbs, necessitate a variation of the postero-anterior technique.

With the patient supine, the head is adjusted so that the general plane of the face is parallel to the film, with the base line at an angle to the film as nearly approximating 90 degrees as possible.

The anode-film distance is increased to eliminate enlargement distortion.

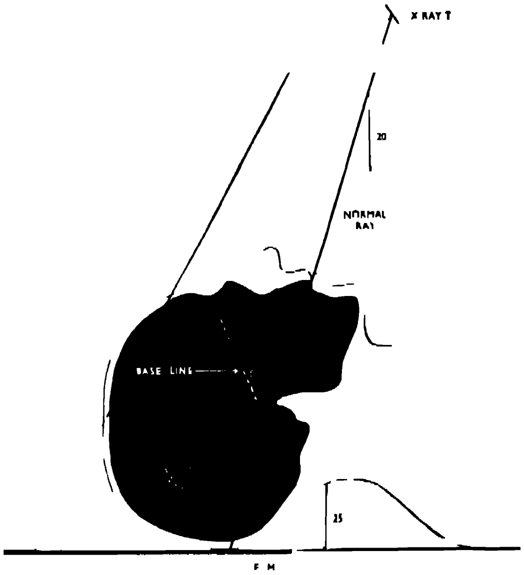
CENTRE over the mouth, with the tube angled at 45 degrees to the baseline; or the tube may be straight, and centred below the chin.

(532, 533, 534)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	57	35	36″	Ilford	Tungstate	—
*75	76	46	36″	Ilford	Tungstate	Stationary
75	200	120	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

* Ward mobile unit.



533

The dry skull illustration (533) shows how the low centring point serves to project the facial bones above the level of the dense base structures of the cranium. Comparison should be made with (531) and the difference in centring noted.

An alternative method for stretcher or bed patients is to follow the technique for the cranial bones given on page 178 (495). With the patient supine, the head is turned through 90 degrees with the nose and chin toward the film and stationary grid, which are supported in the vertical position. The X-ray beam is then projected horizontally toward the vertex of the skull and at right-angles to the film, the result being similar to (530).

NOTE—An additional view of the zygomatic bones is shown on page 198 (560).

534

534a

Skull: Facial Bones

POSITION—30 DEGREES OCCIPITO-MENTAL

This position is used in conjunction with the occipito-mental position (528) to demonstrate injuries to the facial bones, particularly to the lower orbital margins and zygomatic bones (535a).

With the patient in the prone position the head is adjusted with the nose and chin toward the couch and with the base line at an angle of approximately 45 degrees to the film.

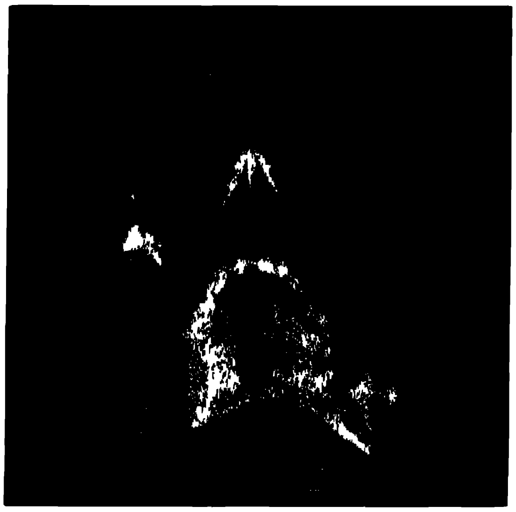
CENTRE through the vertex of the skull toward the lower orbital margin with the tube angled 30 degrees toward the feet.

(534a, 535, 535a)

EXPOSURE FACTORS

kVp	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	230	140	48″	Ilford	Tungstate	Potter-Bucky
75	100	60	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in.



535

535a

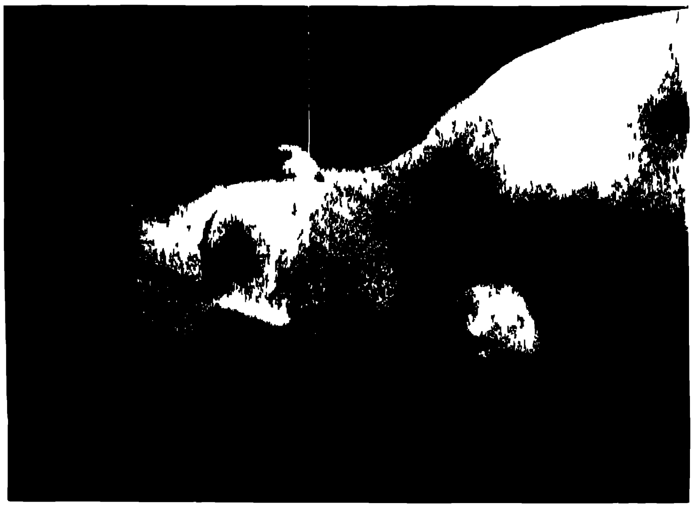
LATERAL

In this position the facial bones overshadow each other, and unless stereoscopic films are taken only gross displacements can be demonstrated.

The head is placed in the true lateral position, with support under the jaw. For further comment on this position reference should be made to pages 174 and 175.

CENTRE over the zygomatic (malar) bone.

(536, 536a)



536

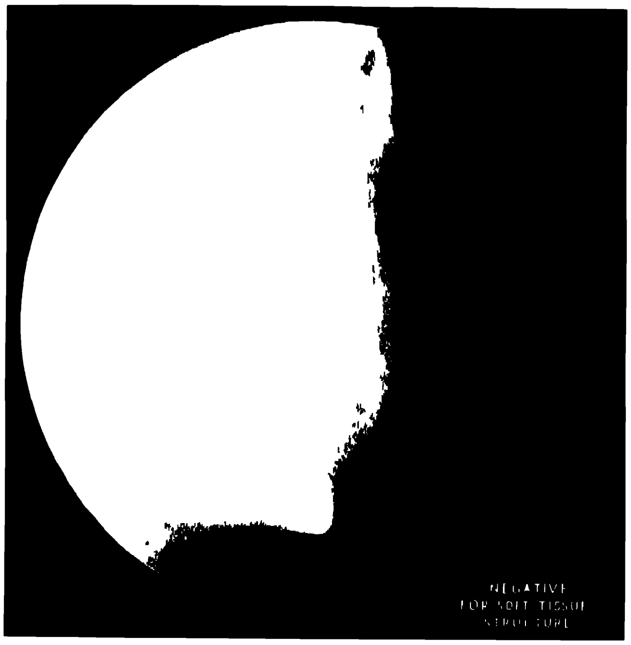
536a

Skull: Facial Bones

537

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	20	12	30″	Ilford	Tungstate	-
60	67	41	48″	Ilford	Tungstate	Stationary
60	100	60	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in. or 10 × 8 in.



538

PROFILE

The head is placed in the *true lateral* position.

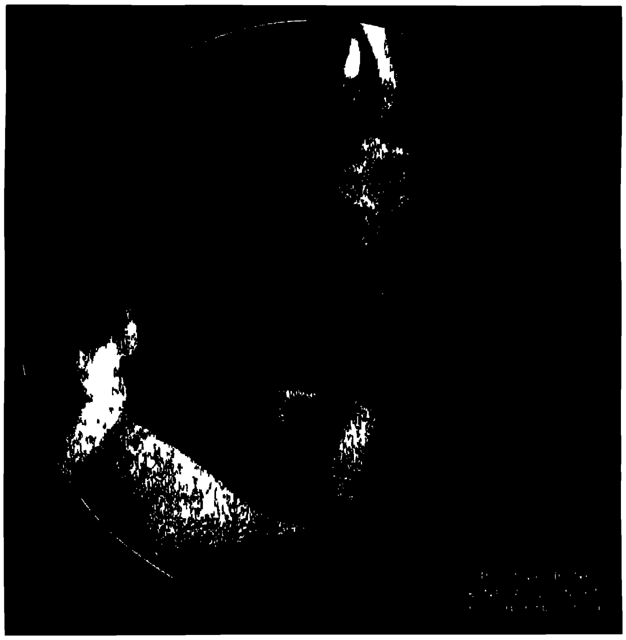
CENTRE over the upper pre-molar region.

(537, 538)

In packing the cassette one film is placed between the intensifying screens and a second film in front of the screens. The result is a fully exposed bone film (537) and a film of the soft structures (538). The former is contact printed on to another film, producing a positive transparency of the bone structures (539) which is superimposed upon the negative soft structure film, the two showing the relationship between soft and bone structures (540).

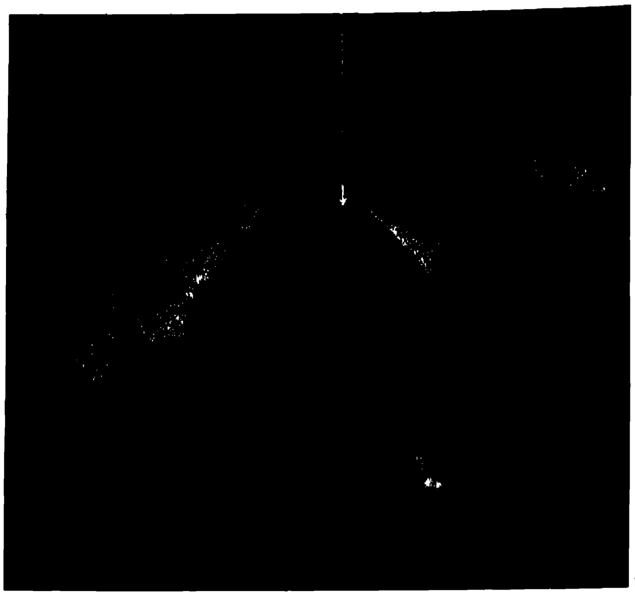
NOTE—This method is sometimes used as a record to show that the original profile outline of the jaws is undisturbed after the fitting of artificial dentures. In positioning the patient it is important to see that the two sides of the mandible are exactly over each other: it is sometimes necessary to position by visual screen examination.

539



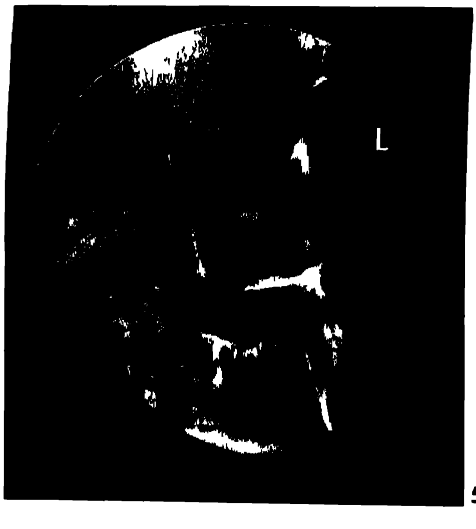
540

Skull: Facial Bones



541

542



543

OBLIQUE

Films taken from the oblique position, especially when viewed stereoscopically, may give further information with regard to minor injuries to the facial bones.

With the patient facing toward the film, the *nose and forehead* are placed in contact with the film support; the head is then turned through 40 degrees toward the affected side and the *chin* allowed to make contact with the film support, thus bringing the supra-orbital margin, the tip of the nose, the zygomatic bone and chin into the same plane.

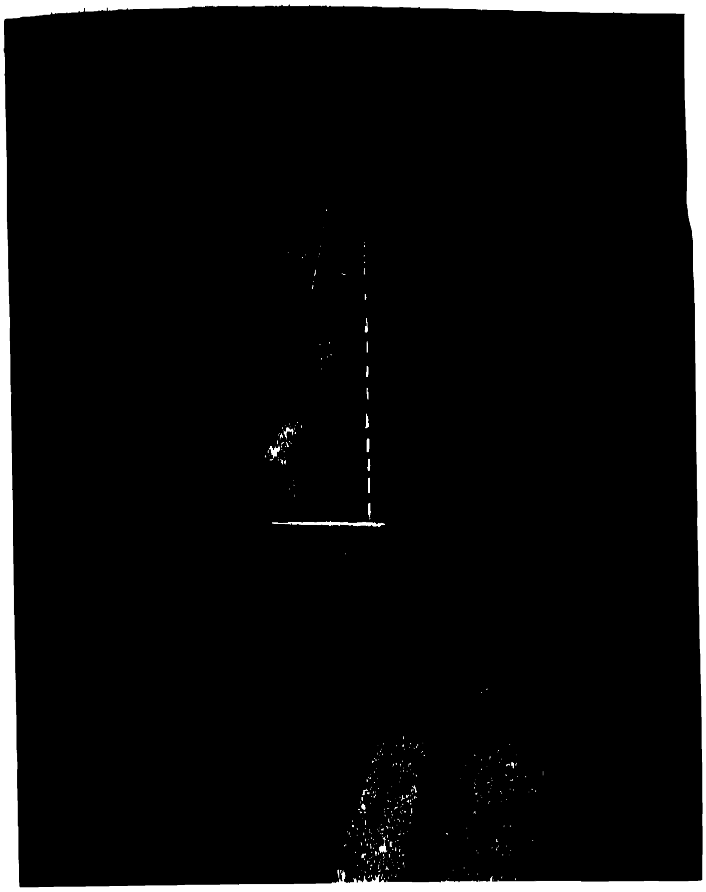
When horizontal positioning is used the *left* or right shoulder is raised on sandbags to bring the *right* or left side of the face toward the film, and the head is carefully immobilised by one of the methods previously given. When erect positioning is used the head clamp allows the head to be moved through the requisite angle, and finally maintains the head in the correct position.

CENTRE below the mastoid process remote from the film, with the tube angled 10 degrees toward the head.

(541, 542, 543)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
67	40	24	30"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.



544

545

546

Skull: Facial Bones

Maxillæ

INTRA-ORAL (1)

Further information regarding injuries to the maxillæ affecting the alveolar processes and hard palate may be obtained by using an occlusal film to produce a supra-inferior view. The occlusal cassette is placed transversely between the jaws.

Intensifying screens are essential, and a special occlusal cassette has been designed for this purpose. The cassette is placed in a fresh cellophane envelope for each exposure, as, apart from the question of hygiene, the film and screens are thus protected against damage.

The patient is seated and the head immobilised. The tube is arranged in the approximate position before the occlusal cassette is placed between the jaws, so that the exposure may be made without undue delay.

CENTRE through the vertex, either with the tube angled 10 degrees forward and to the centre of the cassette, or at right angles to the cassette.

(544, 545, 546)

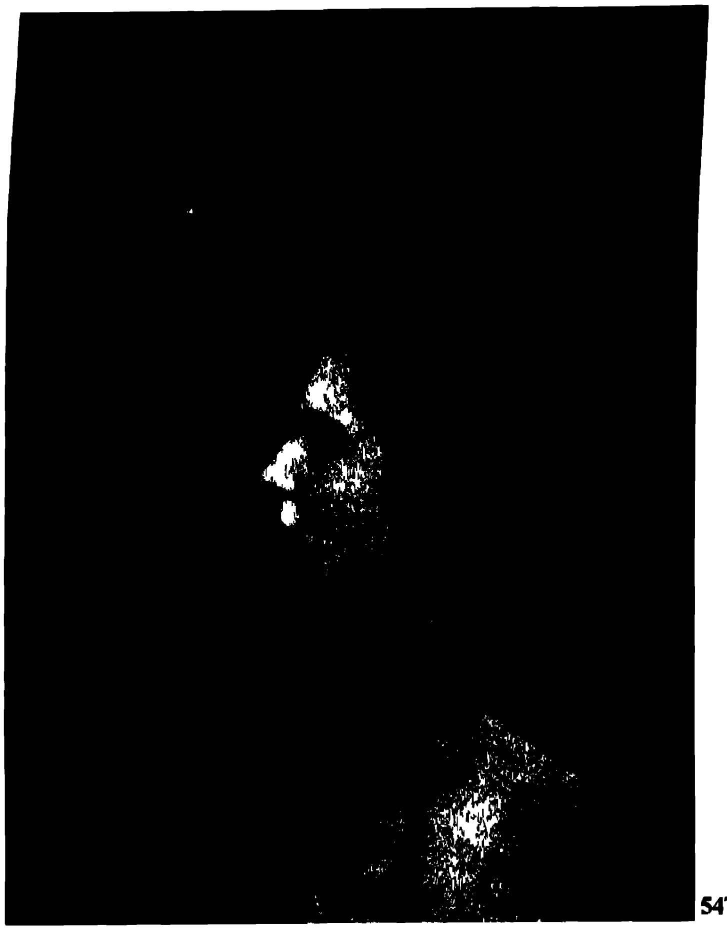
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	27	16	30″	Ilford Occlusal	Tungstate	—
*55	12	7	16″		Tungstate	—

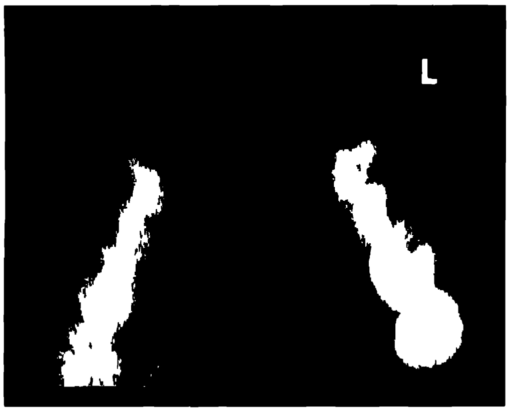
* Dental Unit. Use small cone.

The resulting film (545) shows a plan view of the upper teeth, the maxillæ forming the anterior three-fourths of the hard palate, with the nasal septum in the mid-line and the junction with the palatine bone posteriorly. This radiograph should be compared with the photograph of the dried bone (546).

NOTE—The term *occlusal* is applied to the interdental plane between upper and lower jaws, hence "occlusal" film.



547



548

Skull: Facial Bones—Maxillæ

INTRA-ORAL (2)

Greater detail of the alveolar processes and hard palate may be shown by centring obliquely in relation to the occlusal film, so that the X-ray beam passes through soft structures only as compared with the previous *true occlusal view*, the alveolar processes being shown completely in three separate exposures. Double-wrapped films, packed similarly to standard dental films, are used in place of the occlusal cassette, as intensifying screens are not required.

CENTRAL

The patient is seated with the head supported in position, preferably with the occlusal plane horizontal. The X-ray tube is placed in approximate position before the occlusal film is placed transversely between the jaws, where it is held lightly in position by the upper and lower teeth.

CENTRE through the tip of the nose, with the tube angled toward the face at an angle of approximately 75 degrees to the film.

(547, 548)

RIGHT AND LEFT

With the patient in the same position, the occlusal film is placed well over to right and left sides of the mouth in turn.

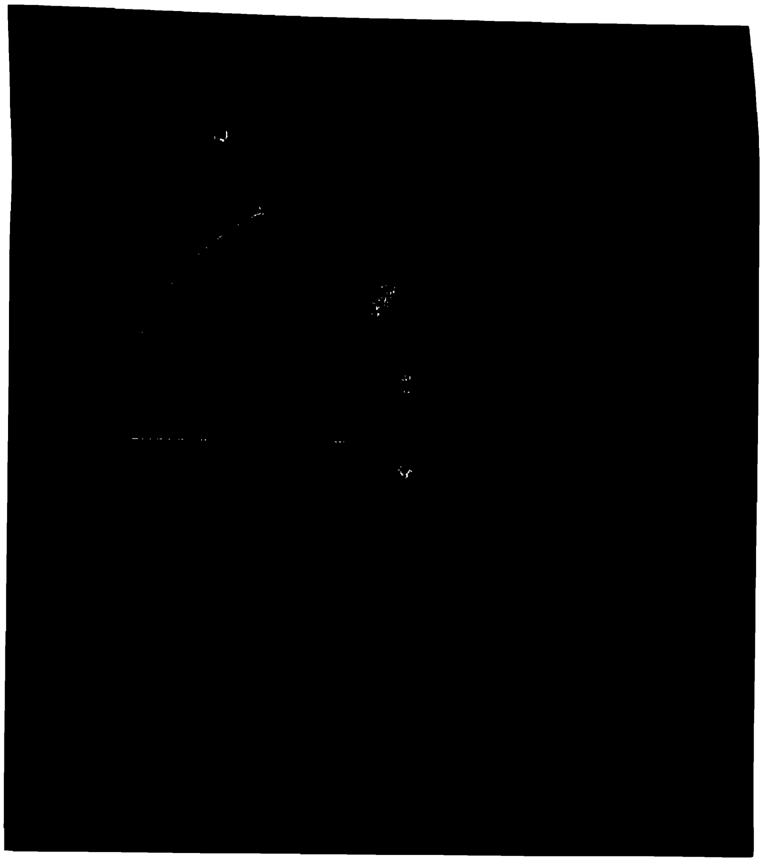
CENTRE the tube high up over the cheek and below the outer canthus of the eye, at an angle of 65 degrees in relation to the film **(549, 550, 551)**.

This positioning with the occlusal film is not confined to the use of the small dental unit. The same views can be obtained with larger units used in the ward or general X-ray department, but it may be necessary to apply a greater anode-film distance to accommodate the larger tube, particularly when it is not of the shock-free type.

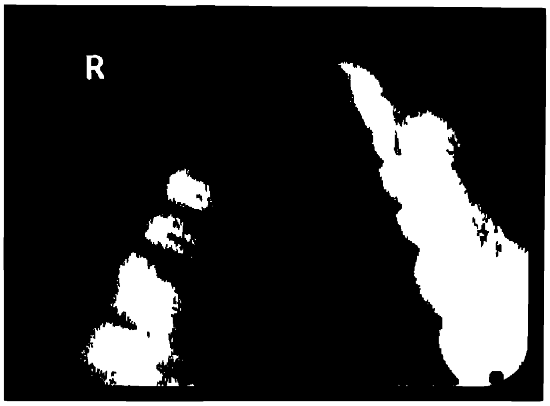
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	53	32	24"	Ilford Oc-	—	—
*55	20	12	12"	clusal	—	—

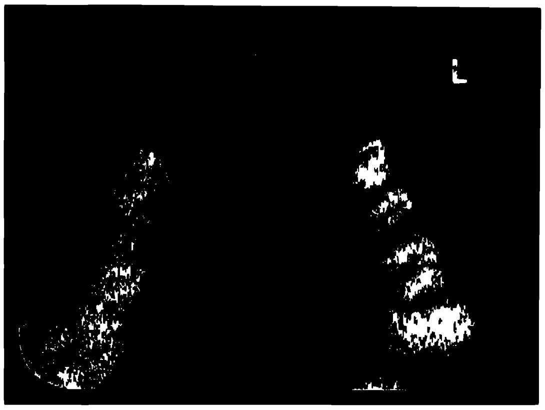
* Dental Unit. Use small cone.



549



550

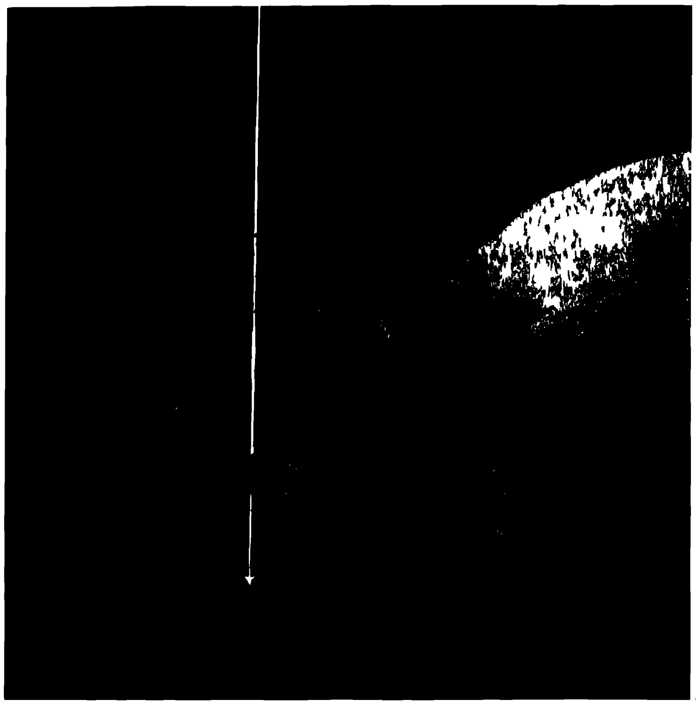


551

Nasal Bones

The two nasal bones are so small and lightly formed as to be grossly over-exposed in films taken to show the general bones of the skull, especially from the lateral aspect. On reference to page 191 it will be seen that in the two films exposed simultaneously the nasal bone is not shown in the bone structure film (537) but is very well shown in *the soft structure film* (538), which was exposed *without intensifying screens.*

All views may be taken in either the erect or horizontal position. Intensifying screens may be used, but the Potter-Bucky diaphragm is usually omitted.


552

LATERAL

(1) The head is placed and supported in the true lateral position, with the cassette, in size either occlusal or half-plate, immediately beneath the nasal bone. The displacement between the nose and the film is compensated for by applying a minimum anode-film distance of 36 inches, except when a fine focus tube is in use (552)

(2) The occlusal film is supported on sandbags and placed in contact with the nose, well above the orbit, the patient being in either the sitting or the horizontal position. As the success of this position depends largely on the flexibility of the double-wrapped films, intensifying screens are not used (553).


553

CENTRE to the root of the nose.

(552, 553, 554)

EXPOSURE FACTORS

kVp.	mA Secs. Ilford Developers X-ray	mA Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	30	18	30"	Ilford Occlusal	—	—
*55	20	12	20"	Ilford	—	—

Dental unit. Use small cone.


554

555

Skull: Facial Bones—Nasal Bones

SUPRA-INFERIOR

It is possible to obtain a second view of the nasal bones, taken at a right-angle to the lateral position This view is not successful in every subject, as there is sometimes a tendency for the nasal bones to be somewhat depressed in relation to the frontal bone or upper jaw, or either of these may be particularly prominent, resulting in the nasal bones being obscured in this position

The occlusal film is placed lengthways between the jaws so that two-thirds of the film project in front of the teeth

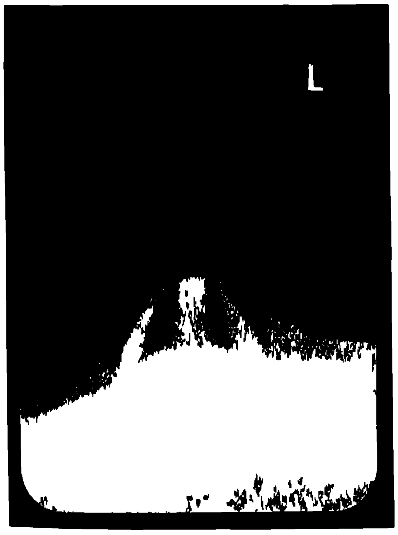
CENTRE from above the vertex and through the root of the nose. Unless a fine focus tube is available the anode-film distance should not be less than 36 inches to accommodate the subject-film distance.

(555, 556, 557, 558)

EXPOSURE FACTORS						
	mA Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	60	57	30	Ilford Oc-	—	
*55	23	14	15	clusal	—	

* Dental unit   Use small cone

556



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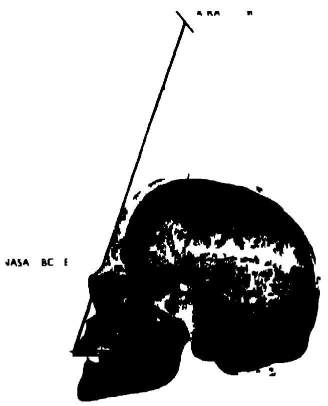
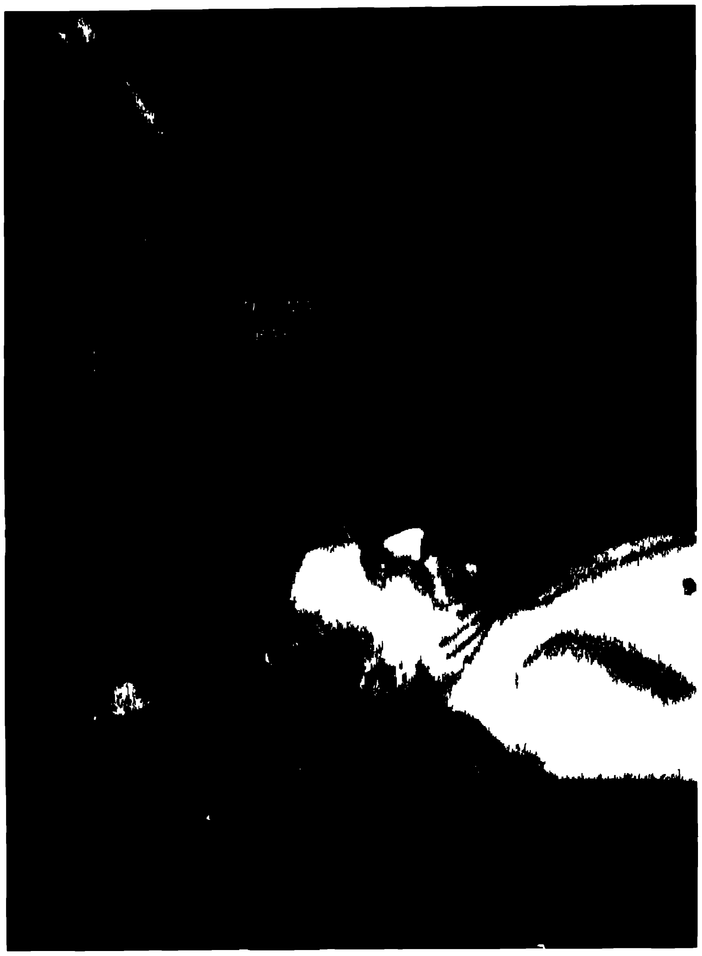


558

Illustration **(558)** of the dry skull is lined to show the method of projecting the nasal bone from the supra-inferior aspect



559

560

POSITION—30 DEGREES FRONTO-OCCIPITAL

An additional view of the facial bones is of interest, and is obtained in taking one of the general views of the cranium as shown on page 180

This view of the skull is usually regarded as terminating at the foramen magnum, but if a sufficiently large film is used it will be seen that an excellent view of the zygomatic bones appears below the dense base structures of the skull In addition, the position is easily maintained by the badly injured subject

CENTRE through the glabella, with the tube angled 30 degrees toward the feet

(559, 560)

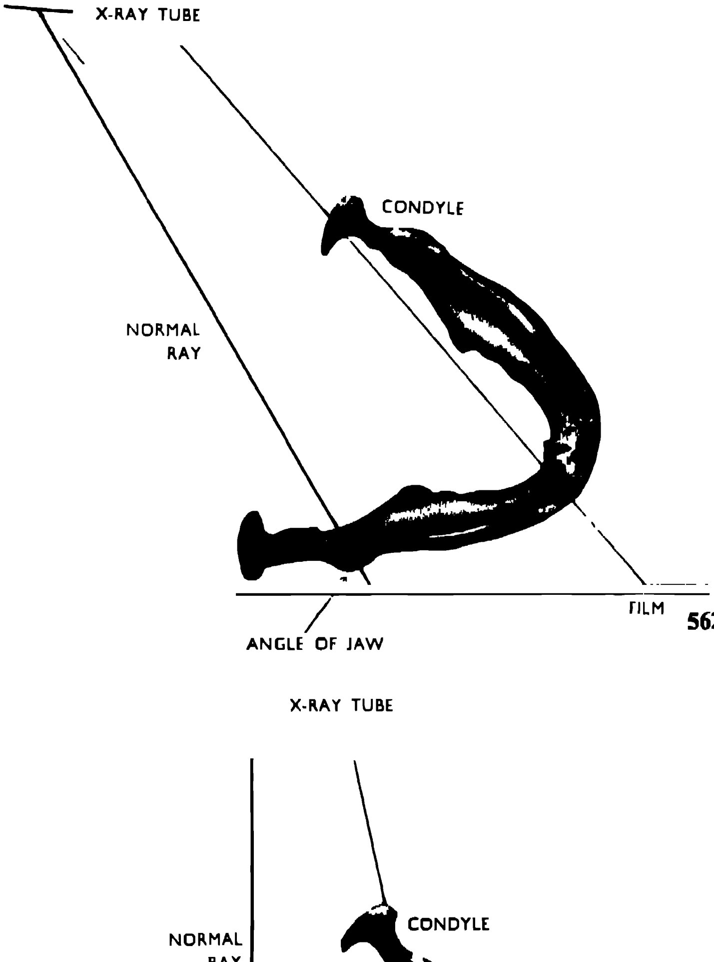
EXPOSURE FACTORS						
kVp	mA Secs Ilford Developers X-ray	 Blue Label	Distance	Film	Screens Ilford	Grid
65	160	100	44	Ilford	Tungstate	Potter-Bucky

Cone to allow for film displacement size of film, 12 × 10 in

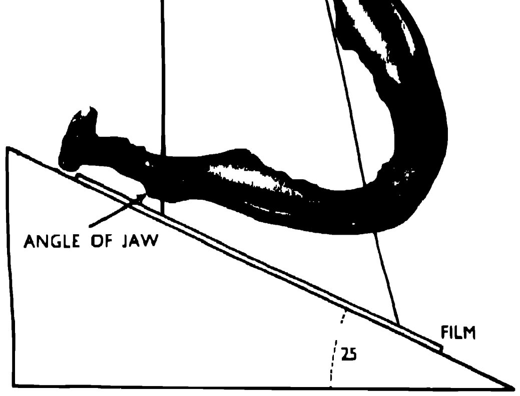
SECTION 10

Mandible

561



562



563

SECTION 10

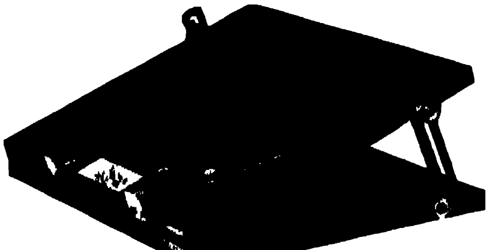
MANDIBLE

Photographs of the dry bone indicate the most important features to be considered in the general radiographic examination of the mandible. These are the *symphysis menti* uniting the two halves in the anterior mid-line of the lower jaw; on each side the *body* extends horizontally backward from the symphysis menti to the angle, supporting the lower teeth along its upper alveolar margin; the *angle* is formed by the junction between the horizontal body and the almost vertical ramus; and the *ramus* extends upward from the angle, branching to terminate in two processes, namely, the *condyle*, posteriorly, with its smooth surface articulating with the temporal bone to form the temporo-mandibular joint, and, anteriorly, the *coronoid process* which moves under the zygomatic arch, the two processes being separated by the *mandibular notch*. **(561)**

From the lateral aspect one half of the mandible exactly coincides with the other, and from the anterior the symphysis menti and adjacent body is overshadowed by the cervical vertebræ. This renders necessary various oblique projections in order to show each part of the bone satisfactorily; either the X-ray tube may be angled in relation to the head **(562)**, or the head angled in relation to the tube **(563)**. Localised radiography of the teeth is discussed in Section 28.

The variations in type of subject are chiefly responsible for the range of positions given in the following pages. The long-necked patient is easily dealt with, but the short-necked subject, with hunched shoulders, and perhaps a less flexible neck, often presents a difficult problem, and considerable ingenuity is required in placing the patient and film in position and in angling the tube in order to obtain useful views. Furthermore, gross injuries to the jaw create their own particular problems.

Although so many of these positions are shown with the patient lying full length on the couch, it should be remembered that, when well enough to do so, patients are usually more amenable to sitting or standing, but care should be taken to see that table and seat are of the right height to allow for the correct position to be assumed; also that the necessary tube adjustment is permissible with the patient in that position, the over-couch tube and unit being replaced by the ward mobile unit when necessary or, better still, by the dental unit when such is available. In many general X-ray departments the tendency is toward full-length couch work.



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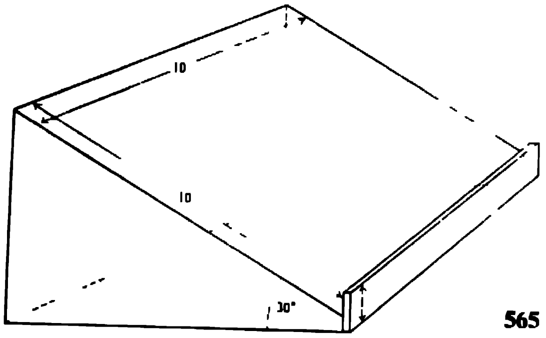

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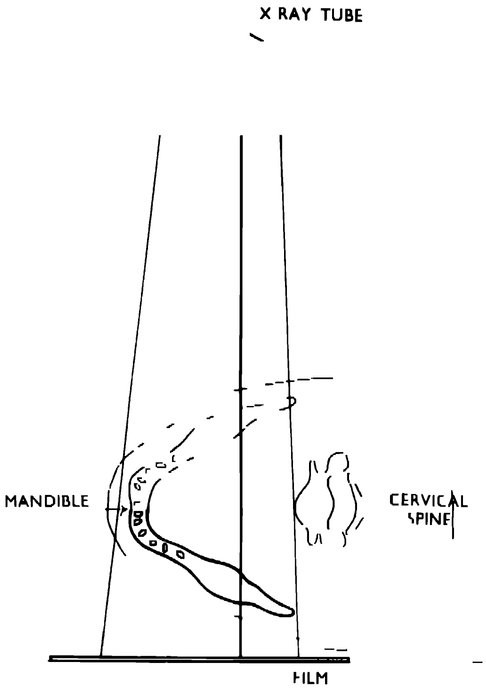

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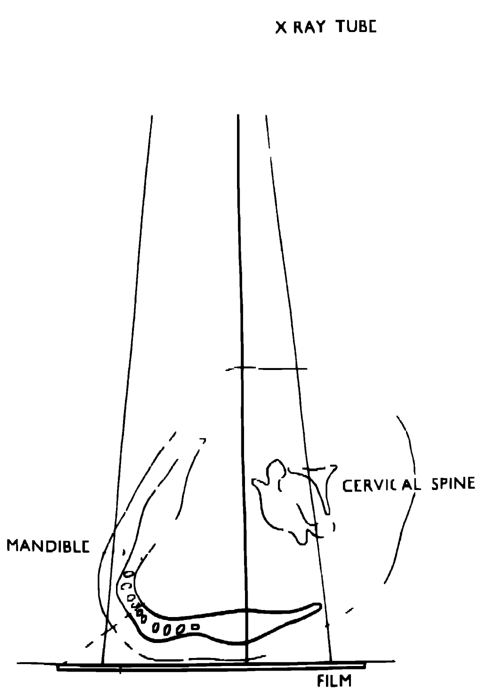


567

Mandible

The angle board, whether of the adjustable type shown in (564) or solid as in (565), is a great asset to jaw technique, but in its absence a sandbag will serve to support the head and cassette in the oblique position which so greatly simplifies tube manipulation.

Illustration (564) shows a typical variable angle board in general use, it having an adjustable slide which allows a variation in the angle up to 25 degrees; when a greater angle is necessary a small block or sandbag is placed under the open end of the angle board. Illustration (565) shows the dimensions of a fixed angle block having a 30 degree angle and a ledge to maintain the film in position, which serves as an alternative to (564). The slope of the cassette renders it necessary for the film marker to be firmly attached to the cassette.

In using the angle board or block the advantage of the oblique surface may be lost by the patient being allowed to use it as a pillow, with the median plane of the head maintained in the horizontal position instead of parallel to the angle board and film.

In placing the head on the angle board it should be remembered that the mandible in contact with the cassette is projected toward the head, and the upper border of the film should, therefore, be on a level with, and parallel to, the lower aspect of the jaw in order that there may be no displacement of the bone shadow from the film. In the variable angle board (564) the adjustable cassette supports allow the film to be placed in the most satisfactory position in relation to the jaw for taking right and left sides as required.

As a complete picture of the jaw cannot be obtained satisfactorily on a single exposure, one or more of the following regional and general views may be necessary to complete the examination:—

- Lateral, to show the vertical ramus, angle and adjacent body (566):
- Lateral, to show the horizontal body and angle (567).
- Postero-anterior general:
- Postero-anterior oblique, to show the symphysis menti and adjacent body:
- Infra-superior general:
- Infra-superior localised occlusal views.

As the general positions for the first two regional views are similar, to avoid undue repetition they are associated in discussing the various methods.

Intensifying screens are used except for the occlusal view, but the grid is unnecessary, save for the general infra-superior view.

568

569

Mandible

Ramus, Angle and Adjacent Body

(1) VARIABLE ANGLE BOARD

The patient is placed in the lateral position, with the head flexed laterally toward the affected side, over the film on the 25 degrees variable angle board. It is essential that the median plane of the head should be parallel to the film and the interorbital line at right angles to the film. A slight forward tilt of the chin avoids superimposition of the cervical spine on the ramus. Wool pads under the shoulder are essential to the patient's comfort.

CENTRE with the tube straight, 2 inches below the angle of the jaw remote from the film.

(563, 568, 570)

EXPOSURE FACTORS

kVp	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	10	6	30"	Ilford	Tungstate	
*55	10	6	20"	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in

*Dental unit

(2) HEAD HORIZONTAL AND TUBE ANGLED

With the patient half-prone, the raised shoulder is supported on sandbags and the head placed in the true lateral position.

CENTRE 2 inches below the angle of the jaw remote from the film, with the tube angled approximately 30 degrees to the vertical.

(562, 569, 570)

It will be seen that these positions give satisfactory general views of the right side of the mandible. The opposite side is projected to a higher level, and can only be shown on making a similar exposure of the left side.

NOTE—For these positions it is important that the chin should be raised in order to prevent any overshadowing of the angle of the jaw by the cervical spine.

571

Mandible

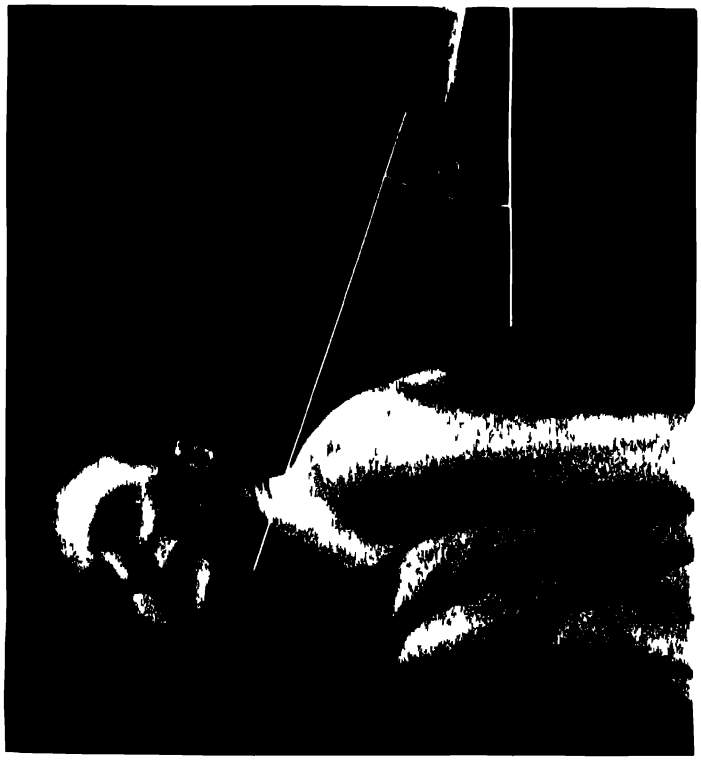
Body and Angle

(1) VARIABLE ANGLE BOARD

With the patient in the same general position as for (568), the face is allowed to turn toward the angle board so that the body of the mandible is in contact with the cassette (571).

A sandbag placed against the head and at the foot of the angle board steadies both head and angle board in position, thus giving the patient confidence to maintain an awkward posture.

CENTRE 2 inches below the angle of the jaw remote from the film, with the tube angled 10 degrees toward the symphysis. (571, 573)



572

EXPOSURE FACTORS

kVp	mA Secs. Ilford X-ray	mA Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	8	5	30′	Ilford	Tungstate	
*55	8	5	20	Ilford	Tungstate	

Cone to size of film, 6½ × 4¾ in or 8½ × 6½ in.

* Dental unit

(2) HEAD HORIZONTAL AND TUBE ANGLED

Using the same general position as for (569), the face is turned toward the film, with the body of the mandible in contact with the cassette (567). This position is improved by raising the cassette on a small block of wood.

CENTRE 2 inches below the angle of the jaw remote from the film, with the tube angled 20 degrees toward the head and 10 degrees toward the face (572, 573).

The resulting radiograph (573) shows a good general view of the body of the mandible, but in this posture the ramus is usually overshadowed by the cervical spine. The molar region of the maxilla of the same side is also clearly shown. This view should be compared with (570).

NOTE—The short-necked, high-shouldered type of subject will be more readily adjusted to the correct position on the angle board when allowed to stand or to kneel on a stool, with the trunk bent forward and the head resting on sandbags placed at the foot of the angle board, and with the arms resting on the couch to support the body and to maintain the posture.

The sitting position shown in (593) is also suitable for the "head straight, tube angled" technique.

573

Mandible

574

575

PATIENT SUPINE, HEAD HORIZONTAL

The patient is placed in the supine position and the head turned toward the side being examined, with the median plane parallel to the cassette, which is raised to support the head in comfort: the opposite shoulder is supported on sandbags.

This position is particularly suitable for the short-necked subject. It is easily maintained, there being less strain to the patient than in the positions previously described, and as both shoulders are well removed from the X-ray field centring is simplified.

CENTRE 2 inches below the angle of the jaw remote from the film, with the tube angled 60 degrees in relation to the *film* and toward the head.

(574, 575)

EXPOSURE FACTORS

kVp.	mA Secs. Ilford X-ray	mA Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	10	6	30"	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.

NOTE—A useful general view of the jaw is obtained, the soft tissues being evenly distributed.

576

577

Mandible

STRETCHER PATIENTS

A badly injured jaw cannot support pressure due to the weight of the head. In such cases the head is best maintained in the supine position, with the film supported vertically. When the injury is anterior the head is turned toward the film to allow the body of the mandible to make contact with the cassette, the position and the resulting film being similar to **(572, 573)**.

CENTRE from the horizontal position, 2 inches below the angle of the jaw remote from the film, with the tube angled 30 degrees toward the head.

(576, 577)

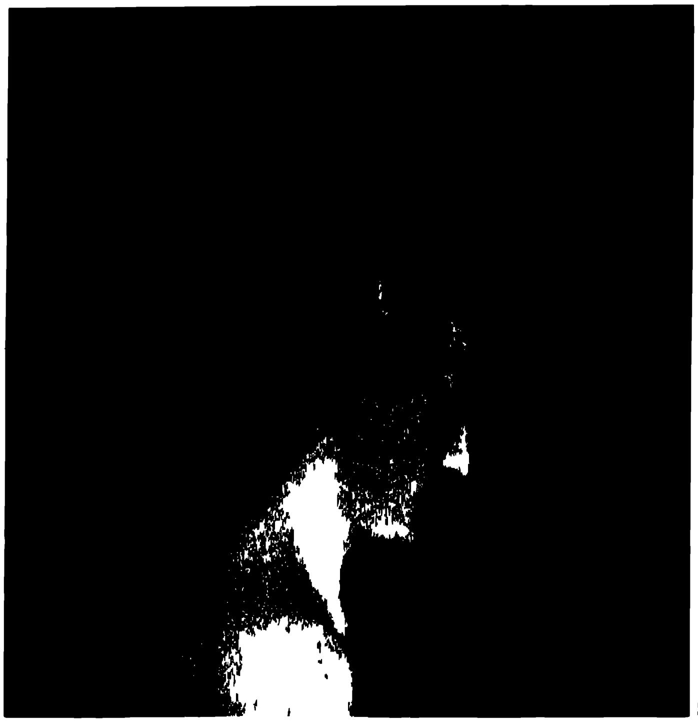
EXPOSURE FACTORS

	mA. Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*60	22	13	36″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in. or 10 × 8 in.
* Ward mobile unit

DENTAL UNIT

The dental unit, with its fine-focus tube, permits a short anode-film distance to be used, and as the examination is frequently carried out in the dental surgery the patient is seated during the examination. The same general principles apply, the angle relationship between patient, film and tube being identical with that used with the larger unit. A small table supports the film, and angle board when used, or the patient may hold the cassette in position on the dental chair head-rest (page 466).



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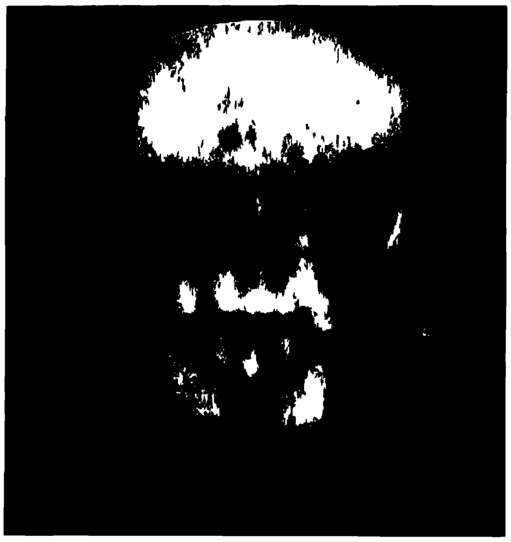
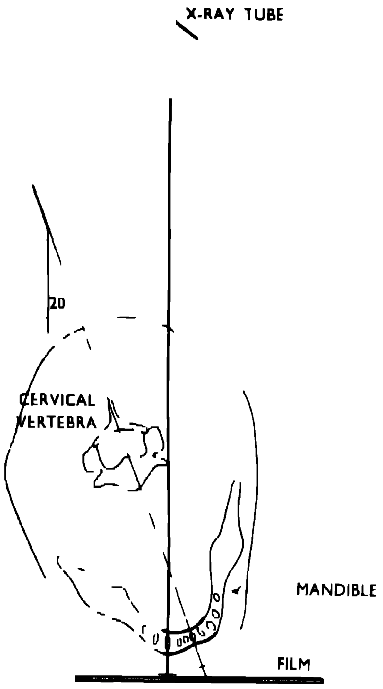


579



580

Mandible

POSTERO-ANTERIOR

It is sometimes necessary to obtain a complete postero-anterior view of the mandible from temporo-mandibular joints to symphysis, any deviation in contour being recorded by comparison of right and left sides. The patient may be examined in either the erect or the horizontal position, the head being placed with the nose and forehead toward the film and being immobilised in position.

CENTRE to the nape of the neck and approximately 2½ inches below the occipital protuberance.

(578, 579)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	50	30	30"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in. or 10 × 8 in.

In the resulting radiograph **(579)** a complete picture of the mandible is shown, with the region of the symphysis and adjacent body overshadowed by the cervical spine. The clearly demonstrated temporo-mandibular joints should be noted. In the presence of gross injuries the alternative positioning described on the next page should be adopted **(581)**.

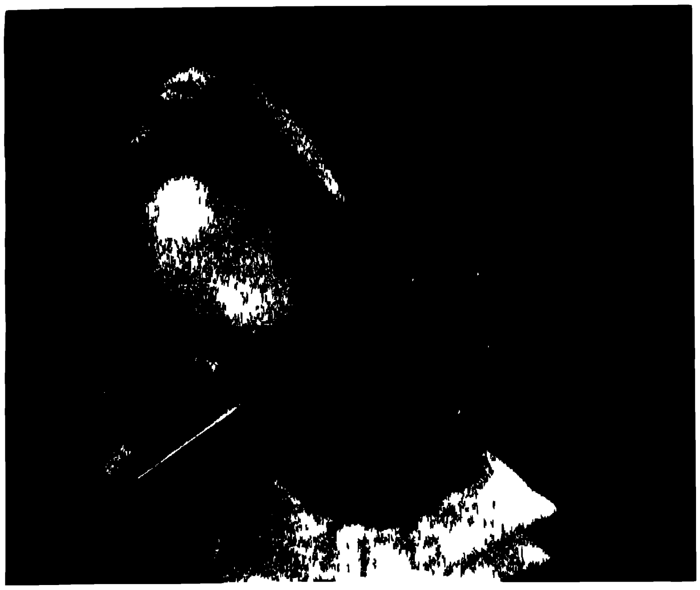
POSTERO-ANTERIOR OBLIQUE

The symphysis menti may be projected clear of the cervical spine by turning the head 20 degrees toward right or left side, as indicated in the cross-sectional diagram **(580)**, to produce radiograph **(583)**. This position for a stretcher patient is shown in **(582)**.

CENTRE 2 inches away from the cervical spine and directly through the mandibular symphysis.

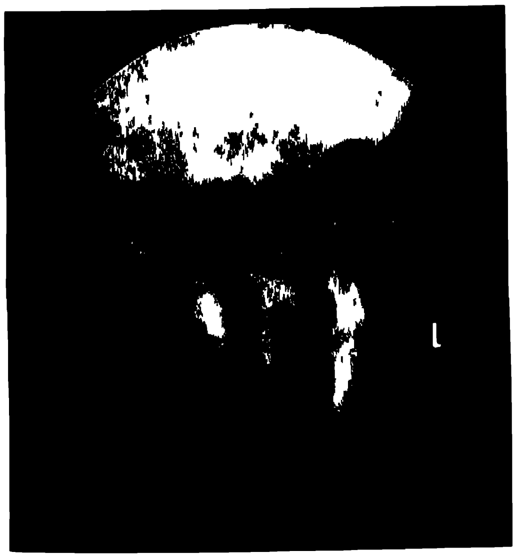
(580, 582, 583)

Both positions may be taken either with or without the Potter-Bucky diaphragm. Radiographs **(579)** and **(583)** were taken with the diaphragm.



581

582



583

Mandible

STRETCHER PATIENTS
POSTERO-ANTERIOR

It is frequently necessary to examine a badly injured patient on the casualty stretcher, when the postero-anterior view is taken with the tube centred from the horizontal position.

With the patient half lateral and the raised shoulder supported on sandbags, the head is turned so that the nose and forehead touch the cassette, which is supported vertically.

CENTRE to the nape of the neck and approximately 2½ inches below the occipital protuberance.

(581, 579)

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*60	35	21	30"	Ilford	Tungstate	

Cone to size of film, 8½ 6½ in.

* Ward mobile unit

NOTE—This view shows the relative positions of fracture fragments.

POSTERO-ANTERIOR OBLIQUE

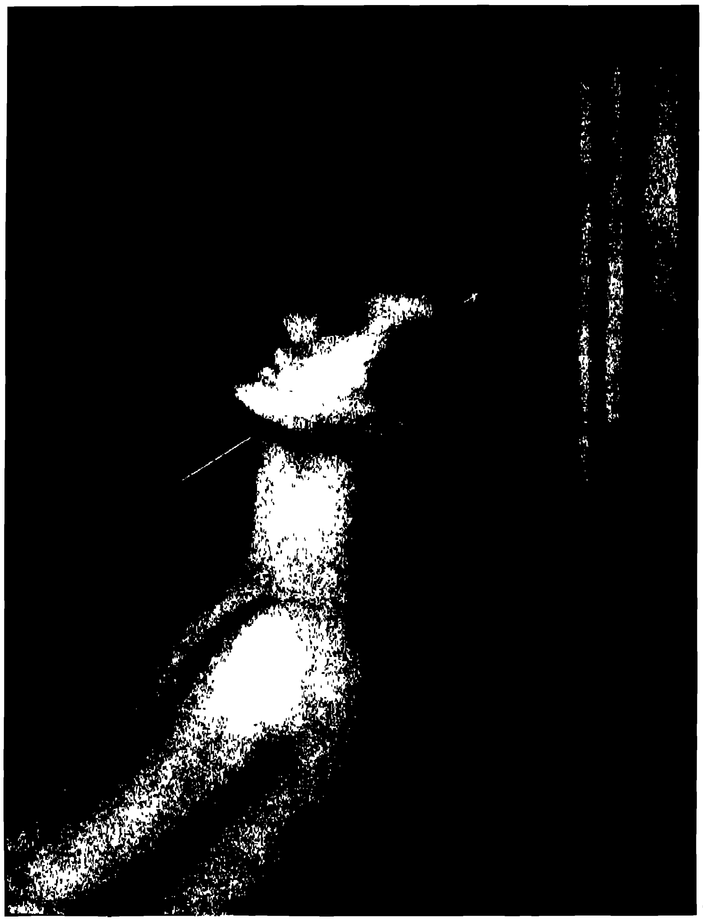
Under similar conditions additional exposures may be made with the head turned through 20 degrees to right or left side as required, so that the symphysis menti and adjacent body may be projected clear of the shadows of the cervical spine, thus enabling greater detail of the injury to be shown.

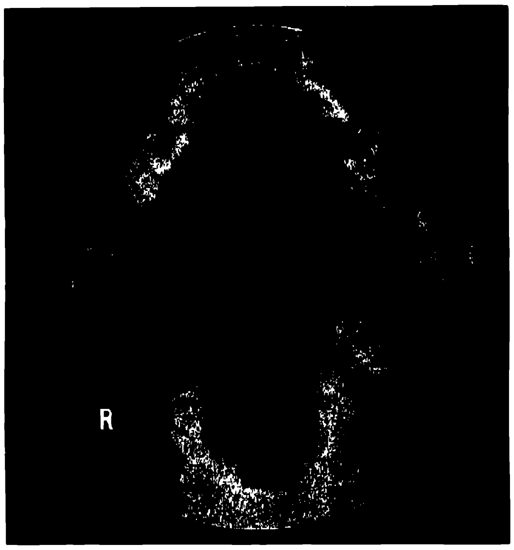
CENTRE 2 inches away from the spine and directly through the symphysis menti.

(580, 582, 583)

NOTE—For these angled views the exposure factors given above should be reduced by 5 kilovolts, there being no overshadowing.

Mandible


584



585

INFRA-SUPERIOR—GENERAL

This position is used to obtain a general outline of the mandible, and to show ventral or dorsal displacement in the event of a gross injury. Exposure may be made with the patient in either the erect or the horizontal posture.

The patient is placed with the neck extended to bring the vertex of the skull into contact with the film support, the ideal position being achieved when the base line is parallel to the film. The horizontal position is shown on page 183, Section 9.

The *anode*-film distance may be increased to avoid distortion due to *subject*-film distance.

CENTRE to the submental aspect, in the mid-line between the angles of the jaw, with the axial ray parallel to the general line of the face and at approximately 105 degrees to the base line.

(584, 585)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	83	50	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.

NOTE—As it is uncomfortable to maintain this posture special care should be taken to see that all is in readiness for the exposure *before* the patient is placed in position.

SUPRA-INFERIOR

As an alternative the reverse of the above position may be applied, the submental aspect of the jaw making contact with the film support and the tube being centred through the vertex of the skull, toward the mid-line between the angles of the jaw. Illustrations of this position are shown on page 237, Section 12. For an injured jaw, however, the strain is greater than in the previous posture.

Mandible

586

INFRA-SUPERIOR—LOCALISED

A localised view of the body of the mandible may be obtained by placing an occlusal film between the upper and lower jaws, any displacement, ventral or dorsal, in relation to the general line of the mandible being shown.

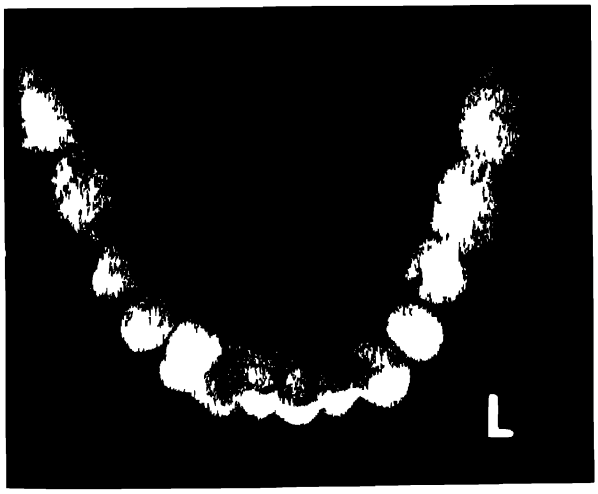
When a dental unit and chair are available the patient's neck is extended over the head-rest, and the unit, when of the shock-free type, is placed well down over the chest and the X-ray beam directed at right angles to the occlusal film. It is, however, frequently necessary to take this view with the larger X-ray unit and without the dental chair, when the patient should be placed in the position shown in (584), or in the horizontal position, with the back and neck extended over pillows and sandbags, as shown on page 183, Section 9. The film is placed transversely and well back in the jaw, being held in position between the lightly closed teeth.

CENTRE at right angles to the occlusal film, from the submental aspect. (586, 587)

EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*55	12	7	10"	Ilford Occlusal		

* Dental unit   Use small cone

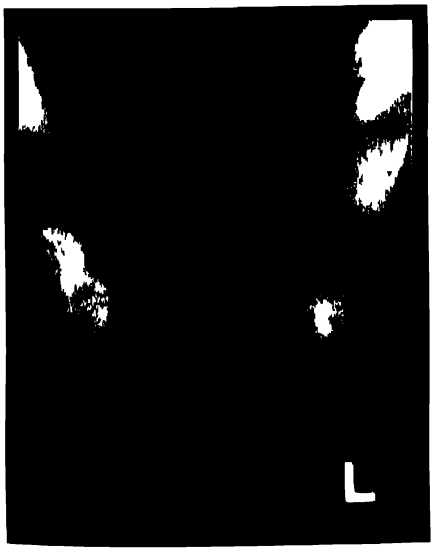


587

NOTE—It is not always possible to take this view, as the condition may be too painful to allow the film to be introduced, or the jaw may be fixed by a head bandage before the patient reaches the X-ray department. In these circumstances the previous general position (584) may be adopted as an alternative.

The occlusal film can also be used to show a detailed view of the bone immediately adjacent to the symphysis menti. With the film in the same position as previously described, the tube is centred obliquely through the jaw at an angle of 45 degrees to the film, as indicated by the broken line in (586) to produce the result shown in (588).

In view of the difficulty of including R or L markers on the small film, in placing the occlusal pack in position the side identification star should, as a routine, be on the *right* of the patient's mouth so that the indentation on the developed film always occurs on the same side. As the mark does not show in the accompanying reproductions left markers have been added to indicate the aspect from which the films should be viewed.



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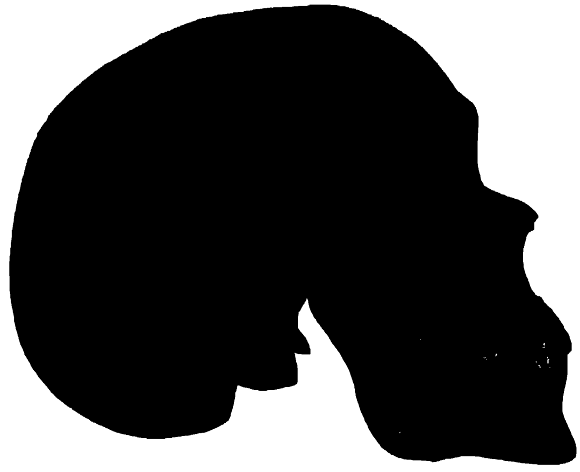

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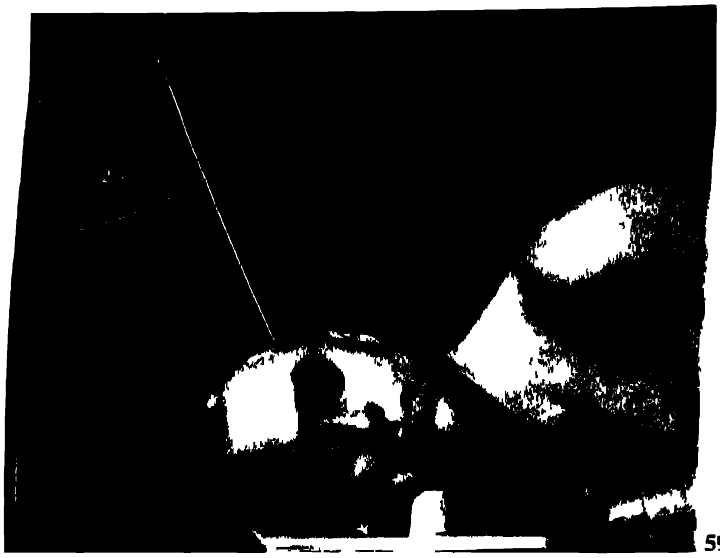

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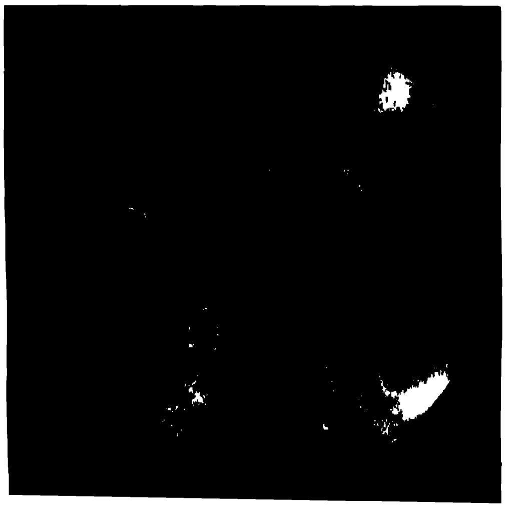
591



592

Mandible

Temporo-Mandibular Joints

The condyles of the mandible articulate with the temporal bones to form the temporo-mandibular joints: these are situated anterior to the right and left external auditory meatus, and as, when viewed from the lateral aspect, these joints are obscured by the dense structures of the temporal bones, it is necessary to project each separately, free from these densities, care being taken to avoid undue distortion (589).

Both sides are always taken, and exposures may be made with the mouth both open and closed (594, 595, 596, 597).

There are several methods by which satisfactory views may be obtained. As in taking the mandible, angling of tube or head, with head or tube straight, may be applied. In addition, the tube may be angled toward the feet, or a short anode-film distance technique may be employed

The temporo-mandibular joints are also shown in general views such as those taken for the mandible, namely, postero-anterior (578, 579) and infra-superior (584, 585).

(1) HEAD STRAIGHT—TUBE ANGLED

With the patient in the half-lateral position and the raised shoulder supported on sandbags, the head is placed in the true lateral position, with the median plane parallel to the film and the jaw supported for immobilisation on a cork or wool pad.

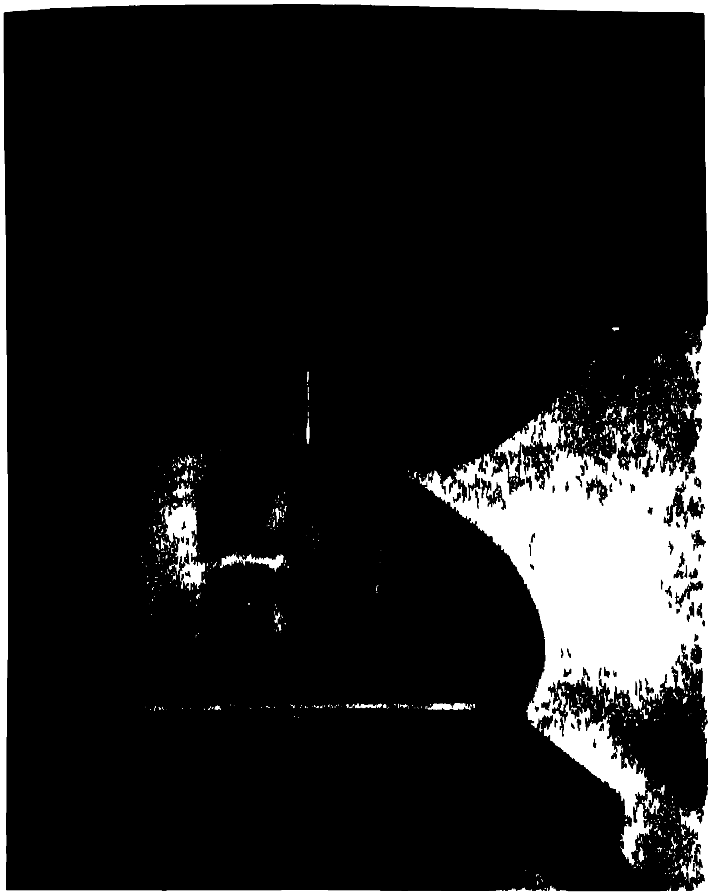
CENTRE 2 inches above the joint remote from the film and directly through the joint in contact with the film, with the tube angled at approximately 25 degrees toward the feet.

(590, 591, 592)

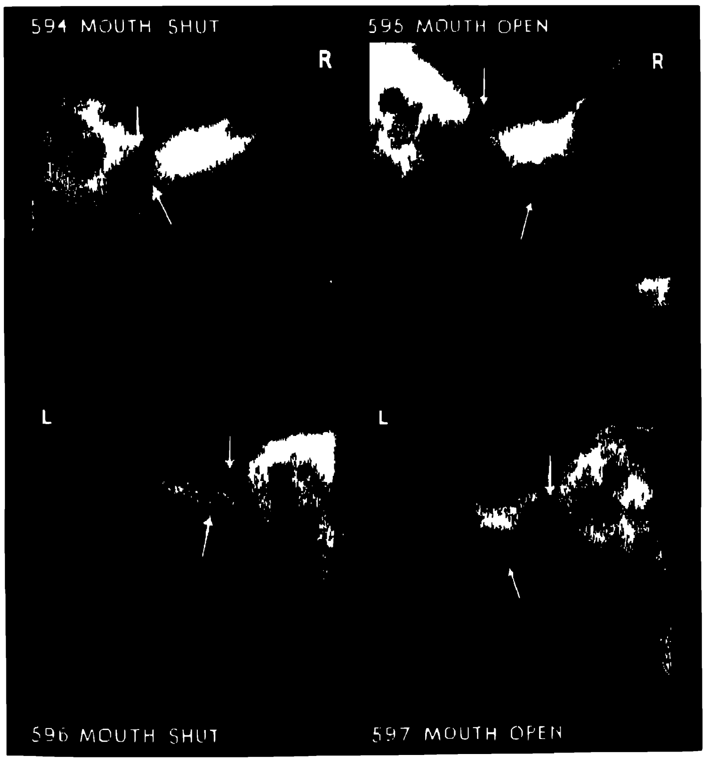
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford Developers X-ray	Blue Label	Distance	Film	Screens Ilford	Grid
55	66	40	30″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.

NOTE—Each film shows both joints, that in contact with the film being sharply defined but overshadowed by the parietal bones, while the opposite side, though somewhat enlarged, is projected clear of the skull structures anterior to the cervical spine.



593



(2) SHORT ANODE-FILM DISTANCE TECHNIQUE

By this method each joint in turn is shown separately and without distortion.

The head is placed in the true lateral position, with the cassette in contact with the joint. The patient is shown seated at the end of the X-ray couch: position **(590)** is equally suitable.

CENTRE directly through both joints, using a small cone, and from an anode-film distance not exceeding 15 inches, the joint remote from the film being approximately mid-way between anode and film. A piece of sheet lead or lead rubber, having a 2½ inch square aperture, may be used to replace the necessarily short localising cone.

The four views shown, of each side with mouth open and mouth closed, may be included on one 10 inch by 8 inch film.

(593, 594, 595, 596, 597)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	16	10	15″	Ilford	Tungstate	
*55	25	15	15″	Ilford	Tungstate	

Cone to size of film, 6½ × 4¾ in

* Ward mobile unit

NOTE—Owing to the short anode-film distance there is a diffused image of the side *nearest the tube*, enabling an uninterrupted view of the side *nearest the film* to be obtained.

IMPORTANT

The number of milliampere seconds applied to each area should be carefully noted and should be considered before additional exposures are made at this *short anode-film distance*. It is essential to use a one-millimetre aluminium filter.

Mandible: Temporo-Mandibular Joints

(3) PATIENT SUPINE—TUBE ANGLED

With the patient supine, the head is allowed to flex laterally toward the affected side so that the parietal region is resting on the cassette. The raised shoulder is supported on sandbags.

CENTRE behind and below the angle of the jaw, with the tube angled 30 degrees toward the head. Each side is exposed separately.

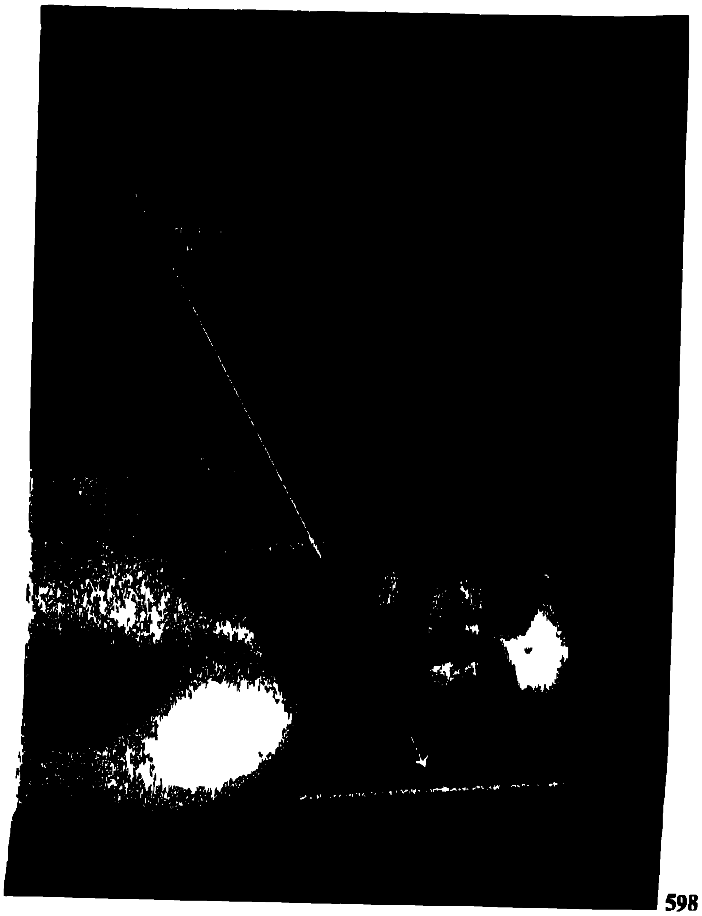
(598, 599, 600)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	16	10	30″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in

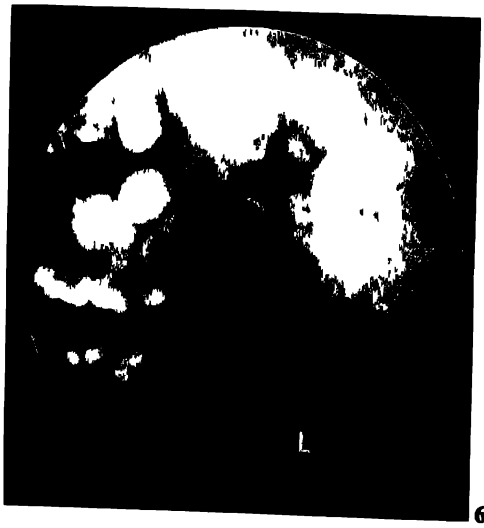
NOTE—This position is easily assumed and maintained by the patient

As will be seen in radiographs **(599)** and **(600)**, the joints are shown clearly and unobscured by other bone shadows.



598

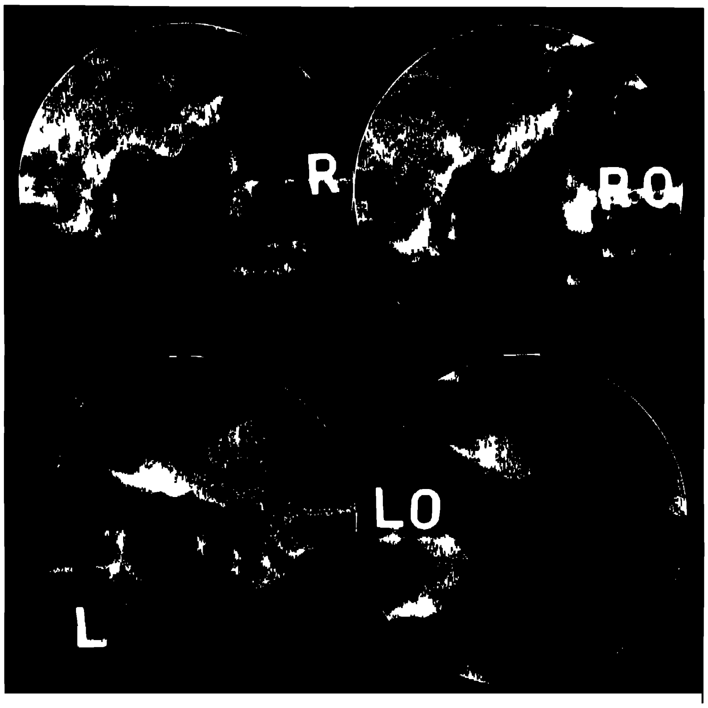
599



600

601

602



603

Mandible: Temporo-Mandibular Joints

(4) VARIABLE ANGLE BOARD

For this view the angle board, adjusted to a 30 degree angle, is used. The patient stands at the end of the couch and, bending, rests the affected side of the head on the angle board, then turns the face approximately 10 degrees away from the film so that the temporo-mandibular joint may be projected clear of the cervical spine and adjacent structures.

CENTRE posterior to and just below the angle of the mandible on the tube side.

(601)

(5) ALTERNATIVE POSITION TO 4

With the patient horizontal, and dispensing with the angle board, the head may be adjusted to a similar angle, as shown in **(602)**, rotation of the head being more easily achieved. The illustration shows the mouth wide open for the second exposure. It is essential to place a 2½ inch cork or a 3 inch bandage between the jaws, otherwise movement during the exposure will be unavoidable.

CENTRE 2 inches below the angle of the jaw proximal to the tube.

(602)

EXPOSURE FACTORS

kVp	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	16	10	30″	Ilford	Tungstate	—

Cone to size of film, 8½ × 6½ in.

NOTE—The radiographic results of positions (4) and (5) are similar to those shown in **(599)** and **(600)**.

(6) HEAD LATERAL TUBE OFF-CENTRED

With the head lateral as for **(593)**, the tube may be centred 3 inches above the level of the temporo-mandibular joints from an anode-film distance of 30 inches or less, when the joint remote from the film may be shown, right and left sides being exposed separately, with the mouth open or closed as shown in the series of radiographs. **(603)**

SECTION 11

Salivary Glands

SALIVARY GLANDS

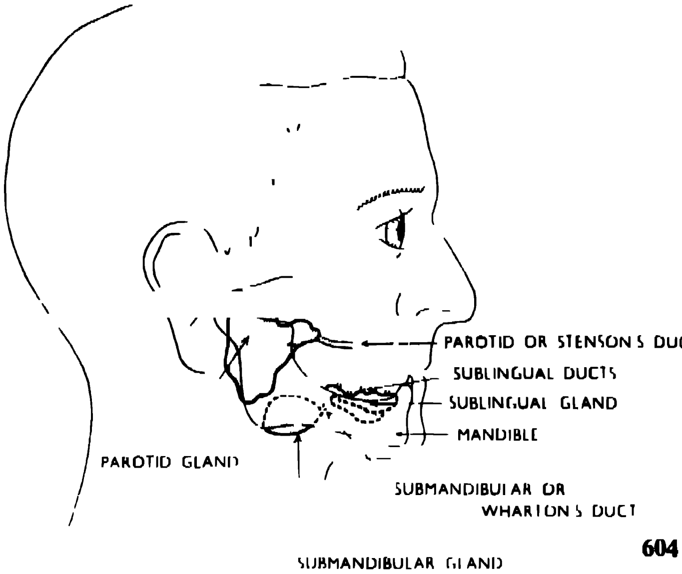
As the radiographic technique for the salivary glands is similar to that applied to the mandible this section follows that devoted to the mandible without regard to normal anatomical sequence in order that reference to the mandible may be the more easily followed.

These glands, consisting of three pairs—parotid, submandibular and sublingual—are situated adjacent to right and left sides and floor of the buccal cavity **(604)**. They secrete the saliva which passes, via the respective ducts, into the mouth.

The saliva flow may be interrupted by the blocking of the ducts by solid accretions, or calculi, some of which are radio-opaque and can thus be shown in a radiograph to confirm clinical diagnosis.

605

606

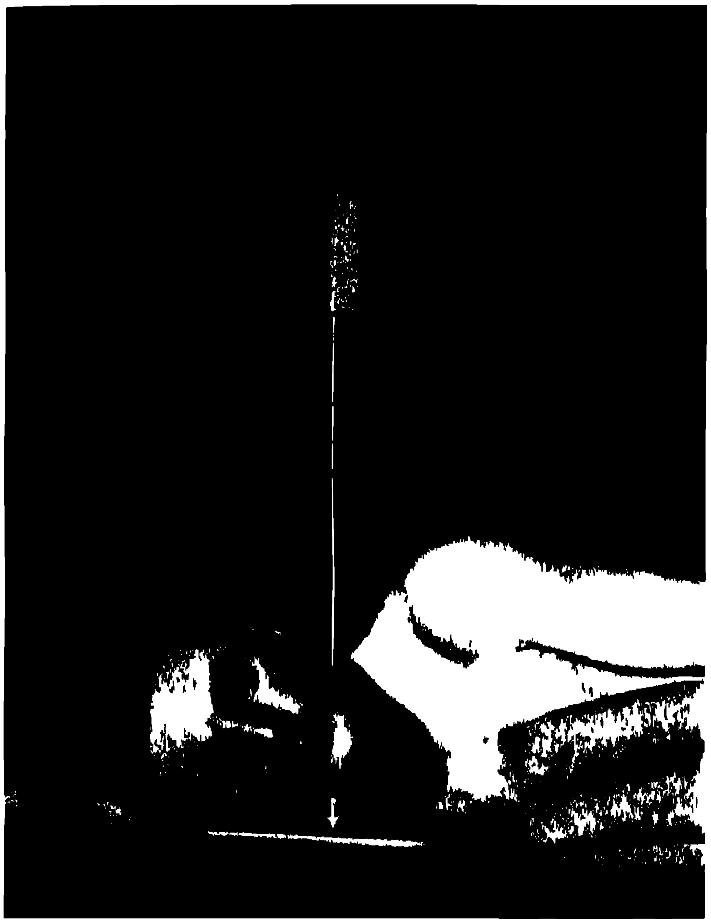


604

Parotid

The parotid glands, the largest of the three pairs, are situated on the right and left sides of the face and slightly in front of, and below, the ears. The parotid (Stenson's) duct leads from the gland, through the tissues of the cheek, to open in the mouth on a papilla opposite the second upper molar tooth. The duct bends inward at the anterior border of the masseter muscle.

The glands are usually radiographed singly following an injection of iodised oil, the examination being termed *sialography*. The iodised oil is injected through the parotid duct, a very fine catheter being used; and the catheter is usually left in the duct during the X-ray examination: only one side is injected at a single sitting. As it is not essential for the injection to be made *immediately* preceding the exposure, the operation may be carried out in another room or department, delay in the X-ray room being thus



607

608

avoided. The resulting radiographs show the duct and the fine ramifications within the gland substance.

Two views are usually taken—lateral and postero-anterior—and alternative positions are also given for each of these views. It should be remembered that *soft tissue structures only* are required throughout this examination, and the exposure factors should therefore be adjusted accordingly.

LATERAL OBLIQUE

Exactly the same position is adopted as for the lateral view of the jaw, and either of the methods described in the previous section may be applied. Illustration **(605)** shows the head straight with the tube angled: the shadows of the two sides, right and left, are separated, thus showing the greatest possible detail in the parotid region.

(605, 606)

LATERAL

An alternative lateral view may be taken with the head in the *true lateral position* in relation to the film, using one of the several postures described in the previous section. The illustration **(607)** shows the trunk in the half lateral position.

CENTRE with the tube straight, over the angle of the jaw.

(607, 608)

EXPOSURE FACTORS

kVp	mA Secs: Ilford X-ray	mA Secs: Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	10	6	26″	Ilford	Tungstate	

Cone to size of film, 6½ × 4¾ in or 8½ × 6½ in.

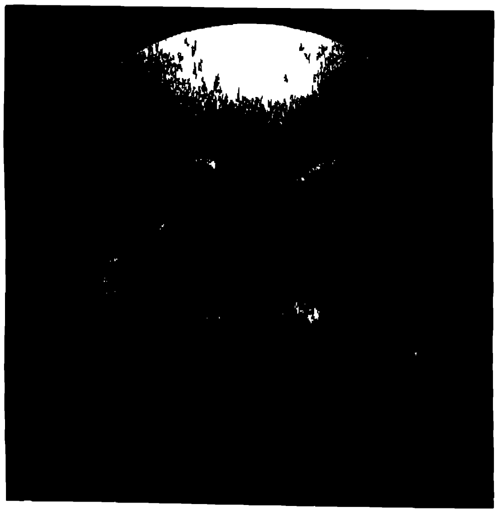
NOTE—In this film the right and left sides of the mandible coincide, and the maximum clear space is shown behind the jaw. The parotid gland is not perhaps seen as satisfactorily as in **(606)**, although there is less projection distortion, but the centring of the tube is more easily applied in subjects where the upper shoulder tends to obstruct the angled beam.

NOTE—An exposure made on a dental film placed inside the cheek will sometimes serve to disclose the presence of a calculus in the duct.

609

610

611



612

Salivary Glands: Parotid

A further view of the parotid gland is obtained from either postero-anterior or antero-posterior aspect of the head, either view being suitable, since the parotid gland is approximately mid-way between the anterior and posterior aspects

In adult subjects the postero-anterior view should be used as the head is easily accommodated to a good position, but in children the supine position is more acceptable, although not always giving a result as good as might be desired owing to the difficulty in placing and maintaining the child in position

POSTERO-ANTERIOR

With the patient in the prone or erect position, the head is placed with the nose and forehead toward the couch or film support, and with the base line and median plane at right angles to the film

CENTRE in the mid-line, $2\frac{1}{2}$ inches below the occipital protuberance

(609, 610)

NOTE—The view shown is similar to **(579)** in the previous section, but the exposure is considerably reduced to show the soft tissues and leave the bones under-exposed

ANTERO-POSTERIOR

With the patient supine, the head is raised on a small non-opaque pad and the chin lowered toward the chest

CENTRE in the mid-line, immediately below the mouth

(611, 612)

EXPOSURE FACTORS

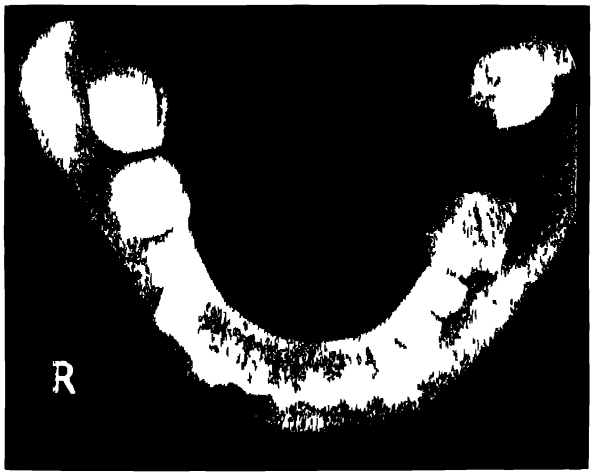
kVp	mA Secs Ilford Developers X-ray	mA Secs Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	33	20	30	Ilford	Tungstate	Potter-Bucky
*55	12	7	30	Ilford	Tungstate	—

Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in and 10×8 in

* Ward mobile unit

In the sialograph **(612)** the parotid gland is clearly demonstrated, with the duct leading to the second upper molar region outlined by the catheter. In this film—of a child—over-exposure necessitated a local reduction in density of the gland area

613



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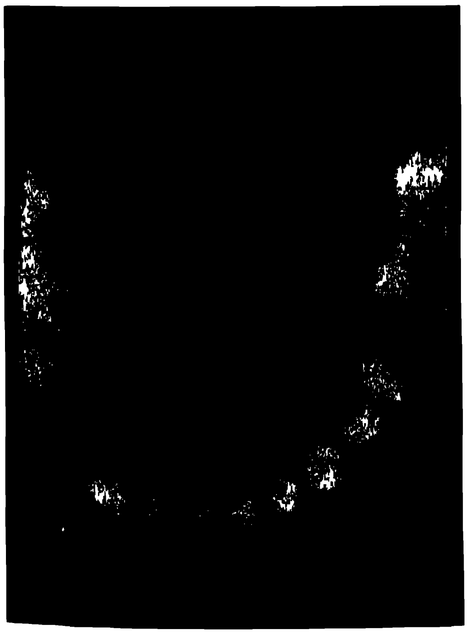


615

Salivary Glands: Submandibular

ANTERO-POSTERIOR *(continued)*

When only one side is to be included it is still necessary to centre to the mid-line, as the parotid gland is mainly superficial to the bone structures and the oblique ray serves to project the soft structures clear of the bone. It is most important to remember that *soft structures* are being radiographed and that for these views films of sufficient density to show good bone detail are not suitable to demonstrate the parotid glands and ducts.

Submandibular (Maxillary)

The submandibular glands are situated on either side of the neck, being internal to, and below. the body of the mandible, the saliva passing via the submandibular (Wharton's) duct, which runs backward, upward and then forward along the floor of the mouth to open on a small papilla at the side of the frenulum of the tongue. Two views are taken, infra-superior and lateral.

INFRA-SUPERIOR (OCCLUSAL)

The patient is seated with the head well back over a suitable support. An occlusal film is placed between the jaws, well back toward the side being examined so as to include the whole of the gland, and is held in position between the lightly closed teeth.

CENTRE from beneath the jaw, with the axial ray at right angles to the film.

(613, 614, 615)

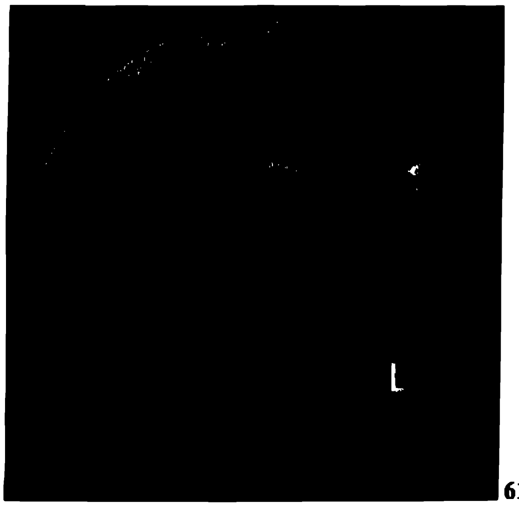
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
*55	7	4	10"	Ilford Occlusal	--	—

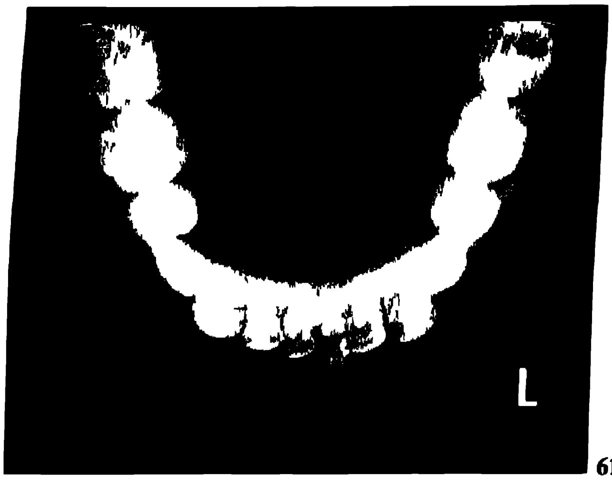
Use small cone.

* Dental unit.

It is essential that this should be a true infra-superior view of the mandible, and when a dental unit is not available alternative methods should be applied with the patient in the position shown in illustration **(509)**, page 183.



616



617

Salivary Glands: Sublingual

LATERAL

Either of the lateral views used for the parotid gland may be applied. Of these the *true lateral* is the more suitable, the result of such positioning being shown in **(616)**

In taking these views the presence of a calculus not sufficiently opaque to show through the bone may be confirmed by depressing the floor of the mouth with a cotton-wool pad under the tongue on the affected side This will press the opacity beyond the shadow of the mandible **(616)**

The calculus is often at the bend of the duct, somewhat medial to the roots of the third molar **(615)**

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	10	6	26	Ilford	Tungstate	—

Cone to size of film 8½ × 6½ in or 10 × 8 in

Sublingual

These glands are situated in the floor of the mouth and beneath the tongue several ducts end by small openings on the sublingual fold on either side of the frenulum and some may open into the submaxillary duct

The same views may be taken as for the submandibular glands, but of these the occlusal view is the more important, and is frequently the only view taken As the glands are more anterior than the submandibular it is not necessary to press the occlusal film so far back in the mouth

(617)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*55	5	3	10″	Ilford Occlusal		

Use small cone

* Dental unit

SECTION 12

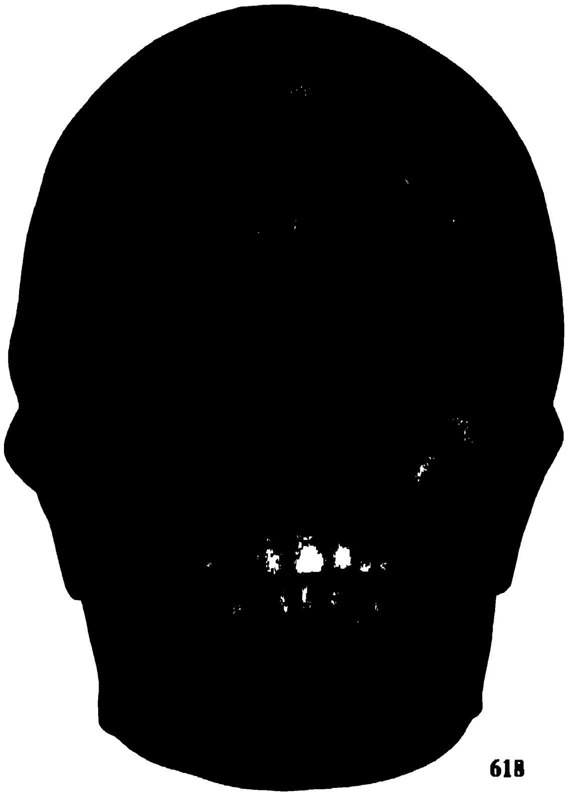
Air Sinuses of the Skull

AIR SINUSES OF THE SKULL

The air sinuses of the skull are air-filled cavities within the bones. They are lined with mucous membrane and communicate with the respiratory tract, and, being air-filled, appear in the radiographs as black shadows.

These sinuses, named the maxillary, ethmoidal, frontal and sphenoidal, are of irregular shape, and vary in form not only from subject to subject, but in the same subject right usually differs from left. The *mastoid* antra and air cells communicate with the middle ear and are discussed in Section 14.

The illustrations of the dry skull (**618**, **619**, **626**) show, respectively, the position of the sinuses when the head is viewed from anterior, lateral and superior aspects.



618

MAXILLARY ANTRA

The maxillary antra are two large sinuses in the maxillæ, situated one on either side of the nose. They extend from below the orbits to above the roof of the mouth and posteriorly, to the zygomatic processes as seen from the anterior and mid-line sections of the dry skull. They are usually the least dissimilar in shape and size.

These sinuses are shown in the occipito-mental, occipito-frontal and lateral positions.

ETHMOID

There are many ethmoidal air cells, divided *anatomically* into three groups—anterior, middle and posterior—and usually referred to *radiographically* as two groups—anterior and posterior. These cells are situated deeply at the root of the nose, as shown in the lateral section of the dry skull. They vary in size and shape, and also in number from four to as many as fifteen on each side. From the median sectional view (**619**) only one side is shown, this extending as far back as the sphenoidal air cells.

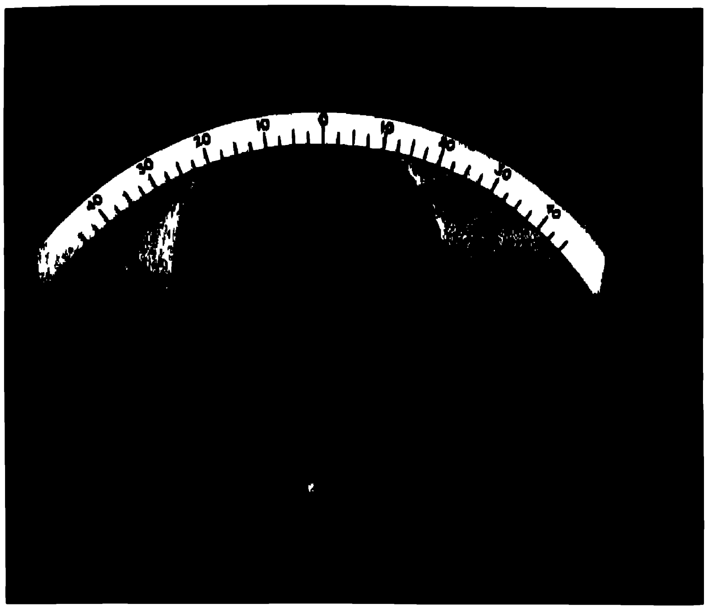
The ethmoidal cells are shown, either anterior or posterior groups, in each of six positions, namely, occipito-frontal using two different tube projections, oblique right and left, mento-vertical vertico-submental and lateral.

619

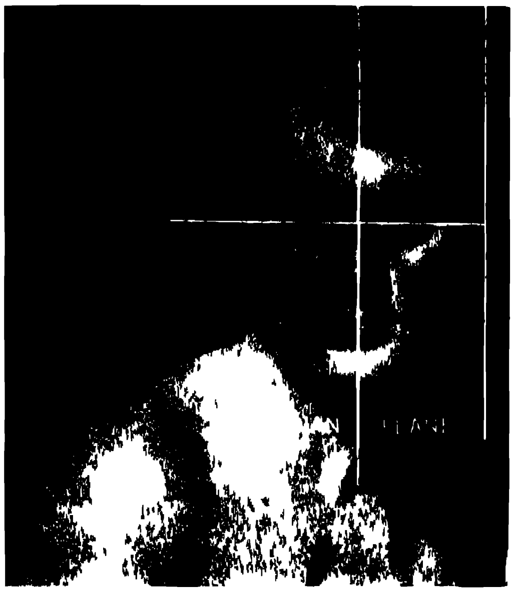
FRONTAL

The two frontal sinuses are situated in the frontal bone adjacent to the fronto-nasal articulation. They are divided by a thin septum, which is frequently deflected to one side, and vary in size both relatively and from subject to subject, some being so small as to be almost non-existent, others covering a very large area, frequently spreading extensively above the roof of the orbits: occasionally one or both may be absent.

These cells are shown radiographically in the occipito-frontal, occipito-mental and lateral positions.



620



621

622

Air Sinuses of the Skull

SPHENOID

The two sphenoidal sinuses are situated side by side within the sphenoid bone, immediately below the pituitary fossa (619), which is in the centre of the floor of the cranium as shown in the horizontal section of the dry skull (626). They are frequently so dissimilar in size and shape as to be difficult to discern, and the intervening septum may be considerably deflected to one side.

From the lateral aspect the sinuses coincide and present in the radiograph a black, kidney-shaped image. Projections made at right angles to the base of the skull show the two sinuses side by side.

In examining the sphenoidal sinuses their position in the skull should be clearly appreciated. Situated as they are, in the middle of the floor of the cranium, they are projected vertically to avoid the jaw bones, tube angulation being adjusted to allow the beam to pass directly through sphenoids and mid-angle of the jaws, or between upper and lower jaws, the vertex point of entry or exit of the beam being unimportant.

Anatomical Landmarks

As all the sinuses cannot be shown satisfactorily in a single film it is necessary to make a number of exposures from various aspects of the head which will be comparable from subject to subject. This necessitates considerable accuracy in positioning the patient in relation to X-ray beam and film, and it is therefore essential to work from fixed points common to all heads.

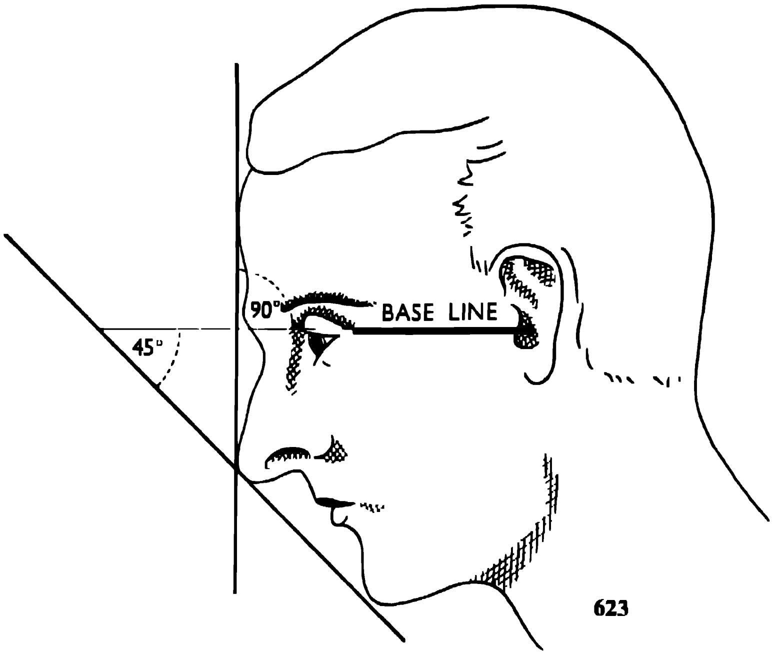
Although the following remarks and accompanying illustrations have already been given as an introduction to general skull technique, in Section 9, it is felt that their importance in this section warrants emphasis by repetition.

MEDIAN PLANE

The median plane divides the head symmetrically into right and left hemispheres, and the correct adjustment of this plane of the head in relation to the film, whether at right angles (620), or parallel (621), is most important.

INTERORBITAL LINE

The interorbital line is an imaginary line through the orbits (621) which serves as a check on the lateral positioning of the head as viewed from forehead to chin. The interorbital line should, if possible, be at right angles to the film, but when this adjustment is not possible the tube is angled to bring the axial ray parallel to the interorbital line.



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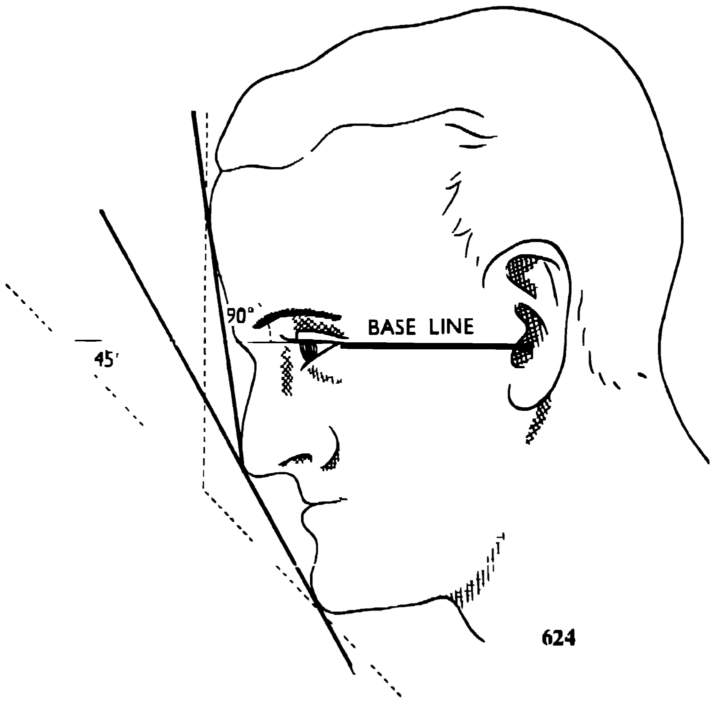
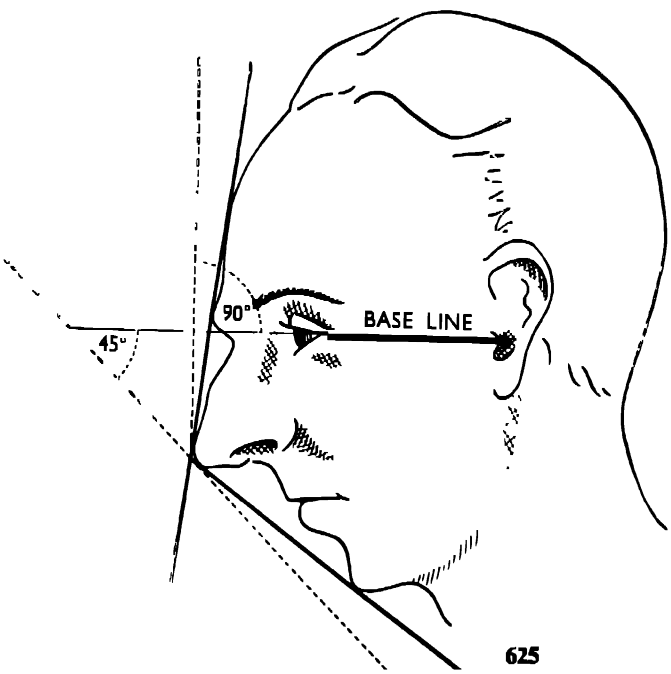


624



625

Air Sinuses of the Skull

ANATOMICAL LANDMARKS *(continued)*

ORBITO-MEATAL LINE

A line drawn between the outer canthus (O.C.) of the eye and the external auditory meatus (E.A.M.) (**622**) is known as the orbito-meatal line: it is used as a *base* line from which to indicate the relative angle between head and film, and will be referred to as the "base line" throughout the text. This is the *radiographic* base line, and should not be confused with the *anatomical* base line known as "Reid's base line," which extends from the *lower border of the orbit* to the external auditory meatus, although the latter is used and quoted by some X-ray workers. As these two lines are separated by an angle of approximately 10 degrees (**622**), the base line to film angle required can be readily adjusted to whichever base line is indicated.

All relationships quoted are as seen radiographically, and do not necessarily apply anatomically.

The importance of working from these landmarks cannot be over-emphasised in view of the general shape of the head and the fact that profiles differ, noses varying in length and foreheads and chins being prominent or receding, as shown in illustrations (**624**) and (**625**) of extreme types, as compared with an average subject (**623**).

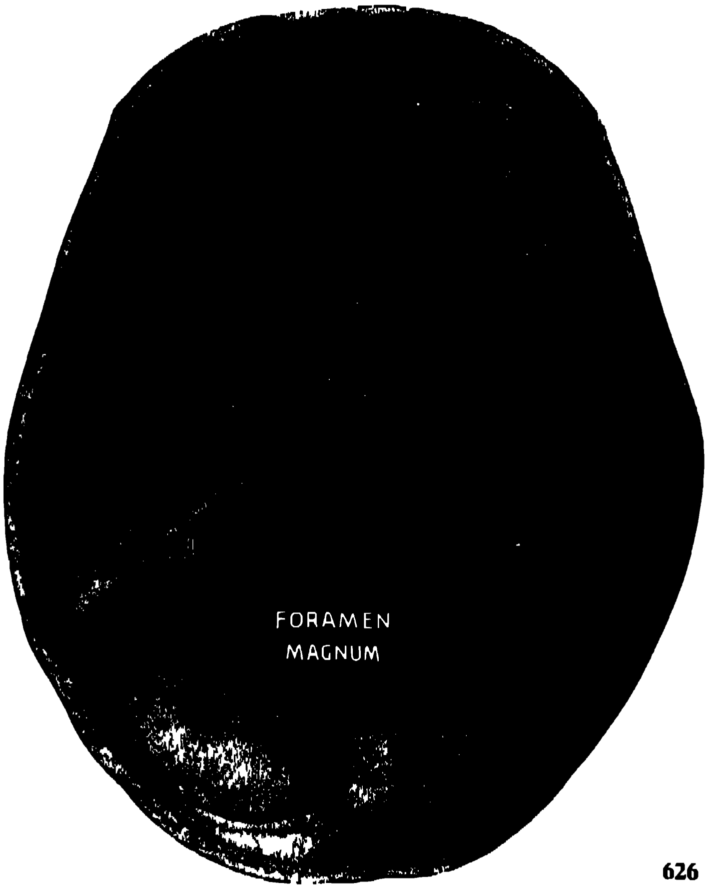
Subject Types

In examining the three drawings of the head the two fixed points should be noted, namely, the outer canthus of the eye and the external auditory meatus, between which extends the base line. The other regions to be noted are those which are adjacent to the film plane when the head is placed in position—the forehead and nose, and the nose and chin.

On drawing a line between the nose and forehead and between the nose and chin, as shown in the diagrams, it will be seen that there are not only great differences in the angles of intersection of these lines, but also in their relationship to the base line.

(**623**) shows the required angulation, with the base line at right angles to the nose-forehead film line and at an angle of 45 degrees to the nose-chin film line.

(**624**) shows a *flat* type of face with an almost straight line between forehead and chin. In this type of subject it is necessary to *displace the nose* away from the film for both positions, so that the films occupy the positions shown by the broken lines, which are correctly adjusted to the base line.



626

627

Air Sinuses of the Skull

SUBJECT TYPES *(continued)*

(625) shows an acute angle between the nose-chin and nose-forehead lines. To accommodate the film in the correct positions it is necessary to *displace both forehead and chin* in relation to the film, as indicated by the broken lines, thus establishing the correct base line to film angle. There are, needless to say, many intermediate types.

Petrous Temporals

Unless the preceding principles are applied to the positioning of the head the sinus fields will be obscured by the overshadowing of the petrous portions of the temporal bones, as all projections are made *to exclude* these dense shadows from the region under examination.

The petrous portions of the temporal bones, the densest structures in the skull, occupy posterior-oblique and central to lateral aspects, as seen in the plan **(626)** and in the lateral view **(627)**. It will be seen that the petrous temporals are sufficiently posterior to the air sinuses to allow of their displacement above or below the particular group of cells to be shown: this is achieved by careful adjustment of the head and the centring and angling of the tube. It is essential to appreciate the position of these dense sections of bone both in the subject and in the radiograph.

Positioning Terminology

It will be appreciated from the previous pages that the terms "nose-chin" and "nose-forehead" are loose terms with which to indicate the positions of the head in relation to the film, and that a qualifying statement as to the base line to film angle is necessary. In recent years these terms have been replaced by:—

(1) OCCIPITO-FRONTAL (642)
for "nose-forehead," this being accepted as indicating that the angle between base line and film is 90 degrees and that the occipital region overshadows the frontal region in the direction of the X-ray beam: and

(2) OCCIPITO-MENTAL (628)
for "nose-chin," this term being accepted as indicating that the base line is at an angle of 45 degrees to the film, and that the occipital region overshadows the mandible in the direction of the X-ray beam.

POSITIONING TERMINOLOGY *(continued)*

Other positions are:—

(3) MENTO-VERTICAL (654)
indicating that the vertex of the skull is toward the film and that the base line is adjusted as nearly parallel to the film as is permitted by the adaptability of the subject, and that the mandible overshadows the vertex in the direction of the X-ray beam:

(4) VERTICO-SUBMENTAL (657)
which indicates that the inferior aspect of the symphysis menti is toward the film and overshadows the vertex in the direction of the X-ray beam, and that the base line is parallel to the film, or within reasonable limits according to the adaptability of the patient:

(5) LATERAL (638)
with the median plane parallel to the film and the inter-orbital line at right angles to the film:

(6) OBLIQUE (660, 661)
right and left, when the head is rotated on its axis by 40 degrees to bring the supraorbital margin, zygomatic bone, mandible and tip of nose parallel to the film and with base line at an angle of 30 degrees to the film support, the X-ray beam being projected from the temporal region on one side to the orbit on the other side.

NOTE—In positions (1), (2) and (6) careful positioning and centring is required to project the dense shadows of the petrous temporals beyond the region of the sinuses under examination.

Vertical or Horizontal

The series of radiographs necessary to demonstrate the individual sinus groups are taken with the head in the erect position as shown in the illustrations. Those workers who prefer to use horizontal technique will see the positions clearly by turning this book through 90 degrees either clockwise or anti-clockwise, as required by the appropriate illustrations. The particular adjustment of the patient on the couch will be seen in Section 9, which deals with the general examination of the skull.

It should be remembered, however, that for any region of the body where there is a possibility of fluid collecting, such as the chest and skull sinuses, erect positioning is important, but when horizontal technique is preferred and generally practised, it should be possible to take a confirmatory view in the erect position when such is shown to be necessary by the pathological appearances in the radiographs. It should not be overlooked, however, that, when necessity demands, *all* fluid levels may also be shown with the patient in the horizontal position.

Number of Exposures

The radiologist indicates the number of films to be taken as a routine. These may vary from one to seven or more. When a series is taken each sinus group is included in at least two separate views, so that the appearances may be checked from film to film and from side to side as regards abnormality, the two films corresponding with the two views taken of a joint.

Arrangement in Text

In the text each position is described and illustrated with photographs, radiographs and line diagrams, the position of the sinus groups being indicated in the radiographs. The six positions of the head, together with the twelve variations of the tube position, are then shown in tabulated form, with the twelve resulting radiographs on the same double page, thus facilitating comparison between the sinus positions and radiographs shown in these pages.

Apparatus

The vertical sinus stand simplifies the whole procedure by providing for the comfortable positioning and immobilisation of the patient and the accurate centring and angulation of the tube. This stand has also been generally adopted as a general radiographic stand for erect positioning. It is important that the essential parts of the sinus stand, namely, tube, stool, film support or Potter-Bucky diaphragm and the head clamp should be arranged to move independently of each other.

APPARATUS *(continued)*

The special skull unit shown in Section 15 allows even greater mobility and accuracy, and has the additional advantage of being equipped with a moving grid of extreme fineness and thinness, which tends to eliminate the enlargement distortion associated with the Potter-Bucky diaphragm; the grid can, moreover, be rotated to approximate the direction of the grid slats to the direction of the X-ray beam according to tube angulation.

Angle board technique for horizontal positioning is not included in this section.

GRID

Sinus films may be taken either with or without the Potter-Bucky diaphragm, many workers preferring to work with a fine focus tube at a short anode-film distance without the grid, claiming that detail and definition are thus greatly improved.

LOCALISING CONE

It is essential to use a localising cone with a small aperture, thus excluding all structures except those immediately adjacent to the sinus group being radiographed. The use of a long cone making contact with the head simplifies tube centring.

THE HEAD CLAMP

The head is immobilised by the use of an adjustable head clamp. This is a useful asset to sinus technique, but is perhaps found to be awkward in unpractised hands.

The head is placed in position with the head clamp central and projecting far enough to grasp the head at the correct angle. The patient should be warned that the clamp is being tightened sufficiently to steady the head only and that there should be no discomfort from extreme pressure. The clamp should be tightened with the right hand, while the left hand on one side of the head-piece checks the pressure applied to the head. When rotation of the head is required with the clamp applied, the central thumb-screw is loosened sufficiently to allow the clamp to be moved under gentle pressure. With a hand on each side of the head-piece the head is firmly rotated to the required angle, as indicated by the protractor, and the thumb-screw then tightened to prevent further movement.

The clamp should be kept well lubricated, and should be mounted on a fixed part of the stand to enable the Potter-Bucky diaphragm and film to be moved independently of the positioned and immobilised patient.

SINUS PROTRACTOR

The sinus protractor is shown in illustration (620). It is designed for use on a flat surface and is large enough for the indicating arm to correspond with the base line of the subject, the extent of the arc being limited, for convenience in use, to the special range of angles required for sinus technique.

Anode-Film Distance

The anode-film distance should be from 24 inches to 30 inches; when it is increased beyond this the posterior bone structures of the skull are in focus, and the bone detail obscures the finer detail of the facial structures. Small films not exceeding 8½ inches by 6½ inches in size may be used, or four views may, by a special method adopted in some departments, be included on one 15 inch by 12 inch film.

RIGHT AND LEFT

IMPORTANT—A right or left marker must be included on every film, preferably a *small* marker, ¼ inch in length.

Patient

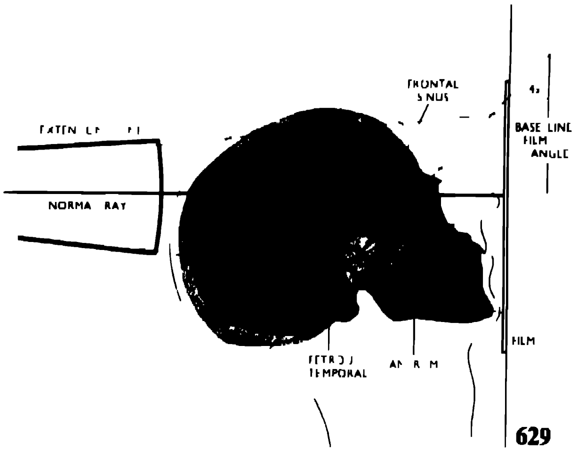
Before the examination all opacities should be removed —these may include artificial dentures, spectacles, ear-rings, hair clips and hair pins, neck ornaments, collar studs and, occasionally, a glass eye.

IMPORTANT—Everything should be in readiness for the exposure to be made prior to placing the patient in position, as some of the sinus positions are difficult to maintain, and delays while the film is being found, and so forth, are unpardonable.

The exposure factors quoted in this section apply to an adult subject having average head measurements.

It should be noted that the positions for the sinuses are not necessarily described in order of importance.

628



629

630

OCCIPITO-MENTAL SHOWING MAXILLARY ANTRA AND FRONTAL SINUSES

As a preliminary to the complete examination of the sinuses the sinus stand stool is adjusted to a comfortable height to suit each patient, with the low back rest supporting the back at the level of the dorsi-lumbar region. The patient's head, facing the film, is raised to bring the nose and chin toward the film; the head is then adjusted in position with the median plane at right angles to the film, and with the base line at an angle of 45 degrees to the film. The film support is locked in position with the horizontal film-centre line at the level of the interorbital line of the head, the clamp having been applied to the bi-temporal diameter of the head for immobilisation. It should be noted that in this posture both nose and chin rarely make contact with the film support.

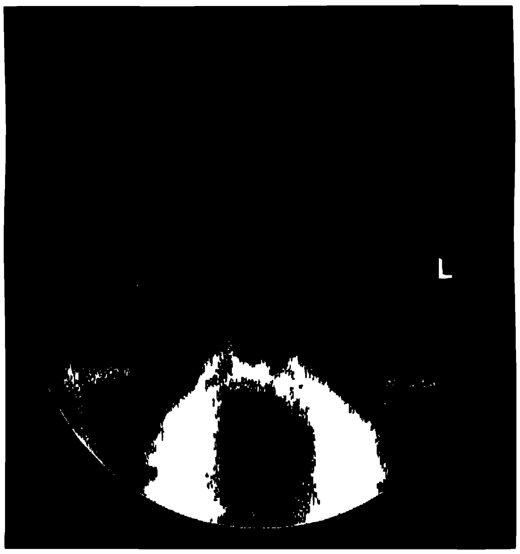
CENTRE above the occipital protuberance, at the anterior level of the lower border of the orbits.

(628, 629, 630)

EXPOSURE FACTORS						
	mA Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	66	40	24″	Ilford	Tungstate	—
75	40	24	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in.

The mid-line section of the dry skull **(629)** is positioned and lined to show the method by which the petrous temporals are projected below the lower limit of the antra as seen in the radiograph. This view is taken to show the antra and frontal sinuses **(630)** and the resulting radiograph is



631

632

OCCIPITO-MENTAL *(continued)*

not acceptable when the lower portions of the antra are obscured, as they may be, by the petrous temporals, as in (**631**), tube angulation then being necessary, as shown in (**632**).

10 DEGREES OCCIPITO-MENTAL SHOWING MAXILLARY ANTRA AND FRONTAL SINUSES

With the patient in the same position as described on the previous page, the tube is displaced toward the head and angled to project the petrous temporals to a still lower level, thus avoiding any overshadowing of the lower regions of the antra.

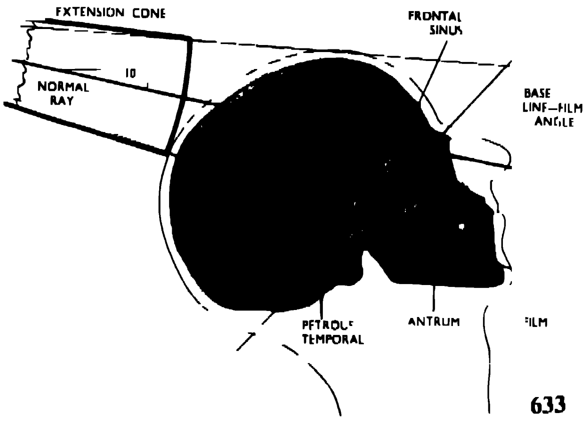
CENTRE with the tube angled 10 degrees toward the feet, and with the axial ray directed through the vertex toward the root of the nose. The film is moved toward the feet to correspond with the downward angle of the axial ray.

(**632, 633, 634**)

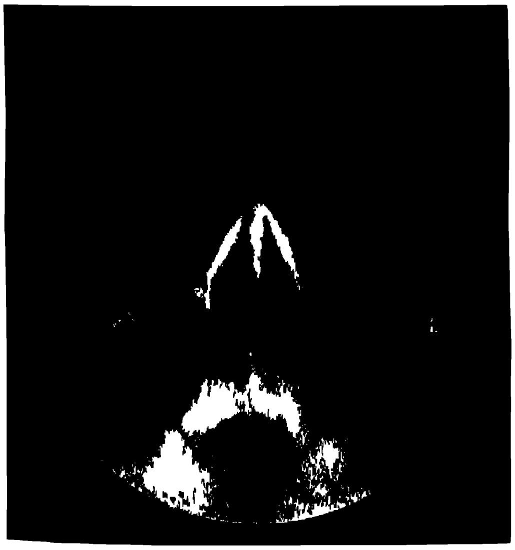
The dry skull section (**633**) has been positioned and lined to show the further displacement of the petrous temporals below the antra when tube angulation is employed, and should be compared with (**629**).

The resulting radiograph (**634**) shows the complete outline of the antra, but the frontal sinuses are foreshortened and are, as is usually the case, over-exposed. This view should be compared with (**630**) and (**631**).

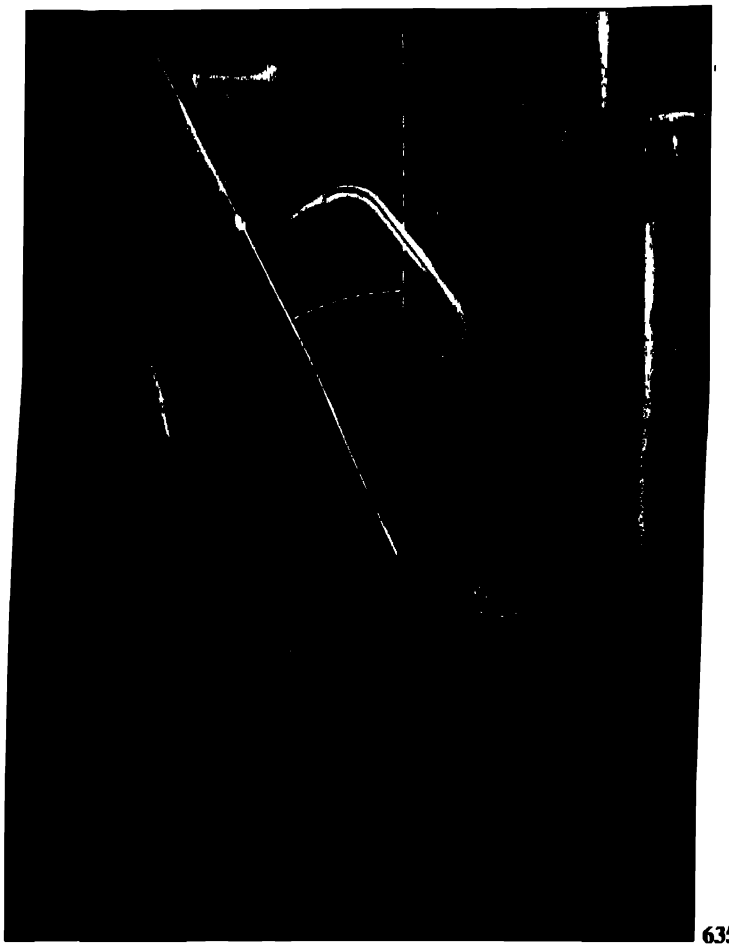
It should be noted that radiograph (**631**) shows an undistorted view of orbits and frontal sinuses, appearances which invariably accompany overshadowing of the lower antra when the base line to film angle is less than 45 degrees.



633



634

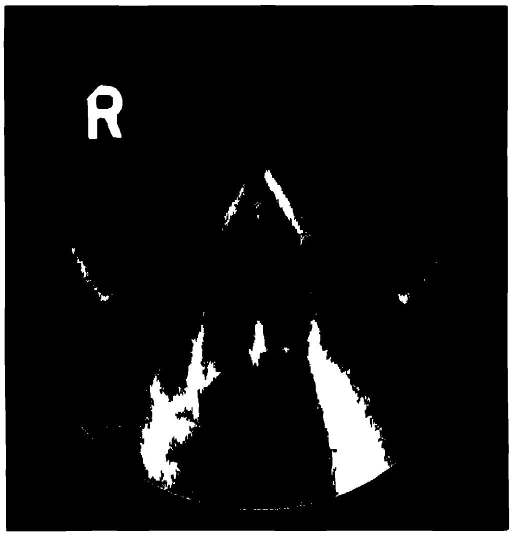


635

OCCIPITO-MENTAL SHOWING FLUID LEVELS

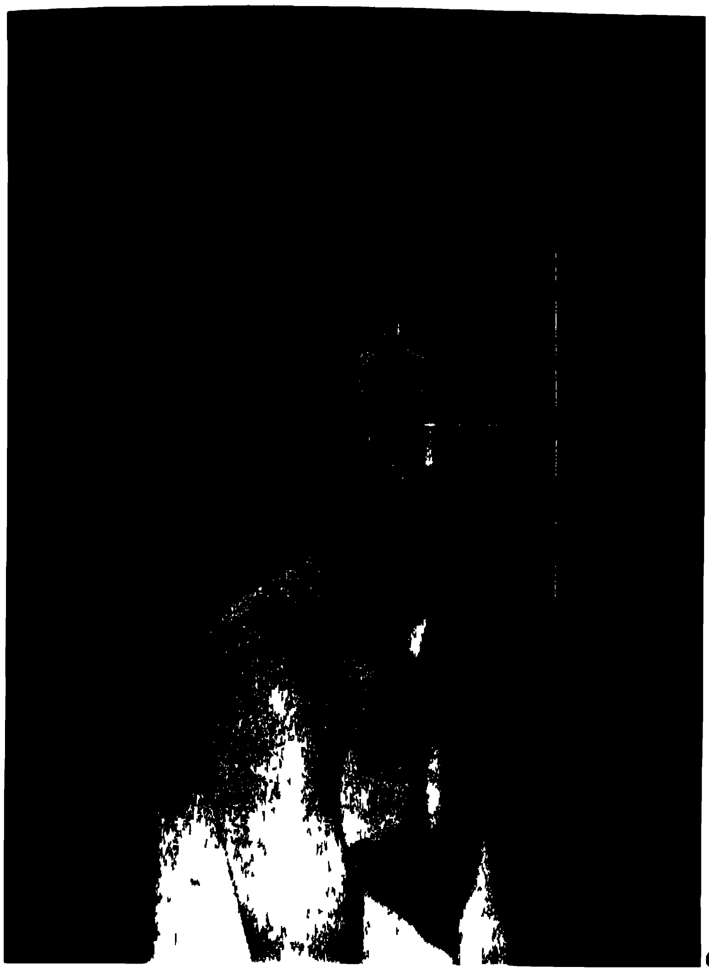
To confirm the presence of fluid in the antra and frontal sinuses an additional exposure is made with the patient in the occipito-mental position, the head being bent to right or left side to the extent of approximately 30 degrees from the vertical (**635**), and the head clamp so adjusted as to maintain the correct displacement of the head. Care should be taken to see that the median plane is at right angles to the film, that the relationship of base line to film is maintained, and also that the head is not rotated outside the range of the small cone of rays from the tube.

Two radiographs taken of the same patient show the result of (**636**) the erect occipito-mental position and (**637**) the laterally flexed occipito-mental position when fluid is present in the antra. Both right and left positions of the head are usually taken.



636

637



638

Air Sinuses of the Skull

LATERAL
SHOWING ALL SINUSES OF THE FACE

From the occipito-mental position the patient is turned to a half lateral position on the sinus stool, to bring the lateral aspect of the head into contact with the film support. The head is carefully adjusted with the median plane parallel to the film and with the interorbital line at right angles to the film. The head clamp is applied to the fronto-occipital region above the level of the frontal sinuses.

CENTRE one inch from the outer canthus of the eye, along the base line. **(638, 639)**

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	25	15	24"	Ilford	Tungstate	—
63	16	10	30"	Ilford	Tungstate	Potter-Bucky

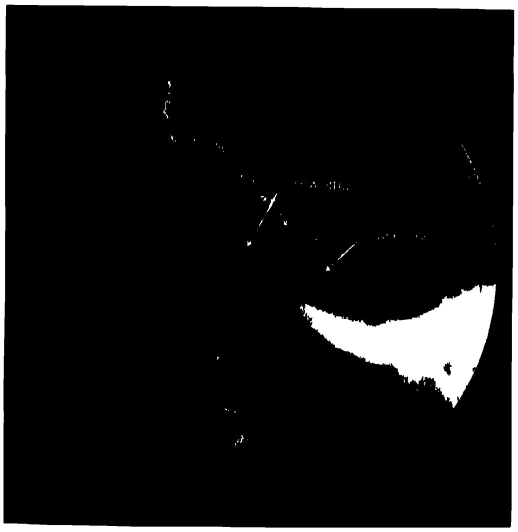
Cone to size of film, 8½ × 6½ in.

In subjects where the correct adjustment of the interorbital line cannot be made the tube is angled to project the axial ray parallel to the coincident orbits. The film is centred to the axial ray.

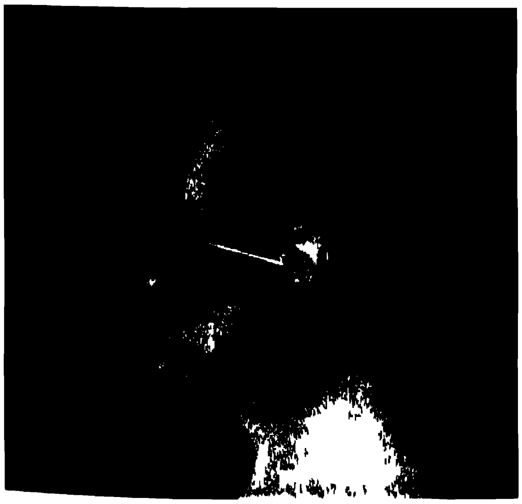
In this general lateral view the sinuses are shown overshadowing from right to left **(639)**.

When a localised view of the sphenoids is required the centring point is varied as follows:—

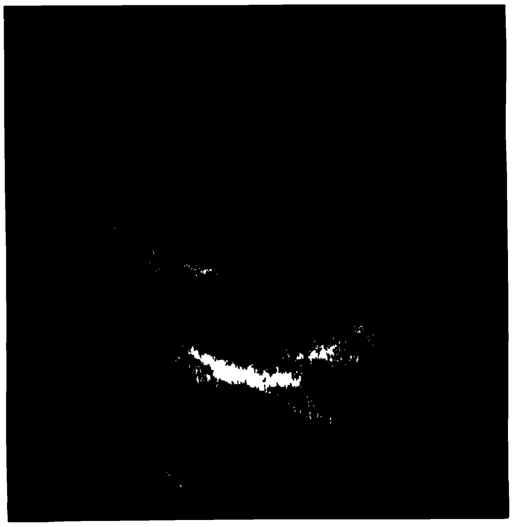
CENTRE one inch in front of and one inch above the external auditory meatus, through the squamous portion of the temporal bone, using a small extension cone. **(640, 641)**



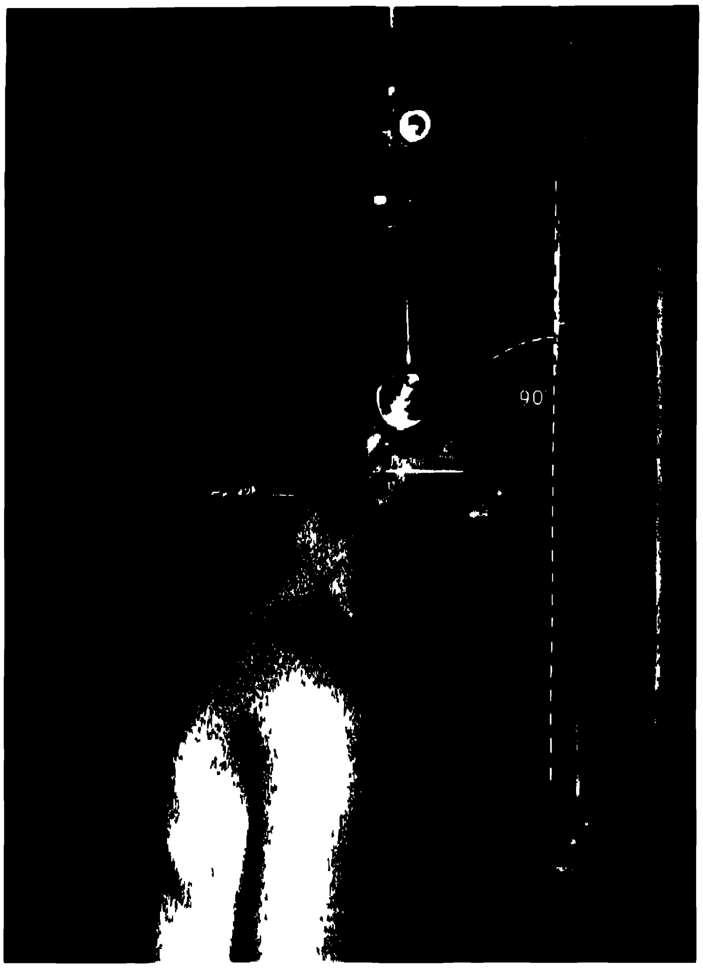
639



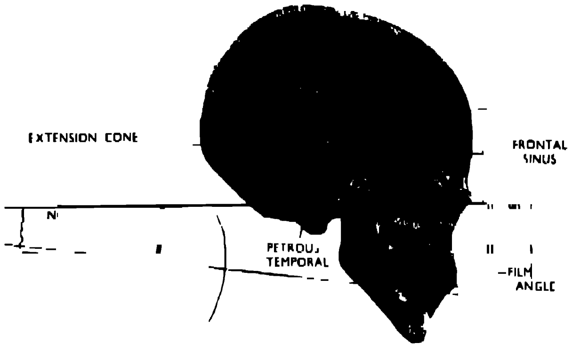
640



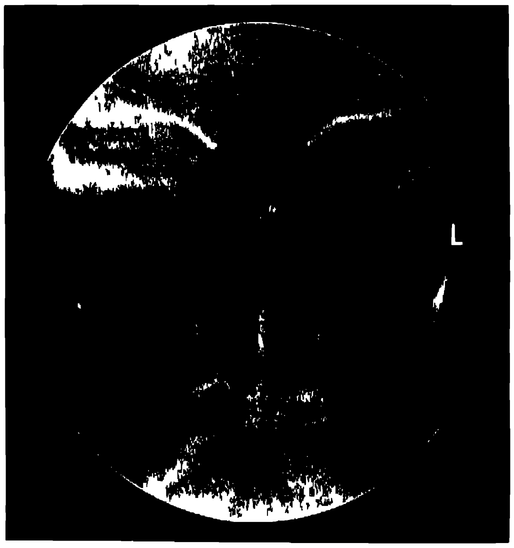
641



642



643



644

Air Sinuses of the Skull

OCCIPITO-FRONTAL SHOWING MAXILLARY ANTRA, ETHMOIDAL AND SPHENOIDAL SINUSES

In this position the head is flexed slightly forward on the spine to bring the nose and forehead in line with the film support. Applying the sinus protractor, the base line-film angle is adjusted to 90 degrees, the median plane-film relationship also being carefully checked to ensure a symmetrical view being obtained.

The slight downward movement of the forehead automatically raises the posterior base structures of the skull in relation to the film, so that the petrous temporals obscure the orbits, leaving the antra and ethmoidal cells to be clearly defined below the level of the cranial bones.

CENTRE $1\frac{1}{2}$ inches below the occipital protuberance, through the nape of the neck toward the antra.

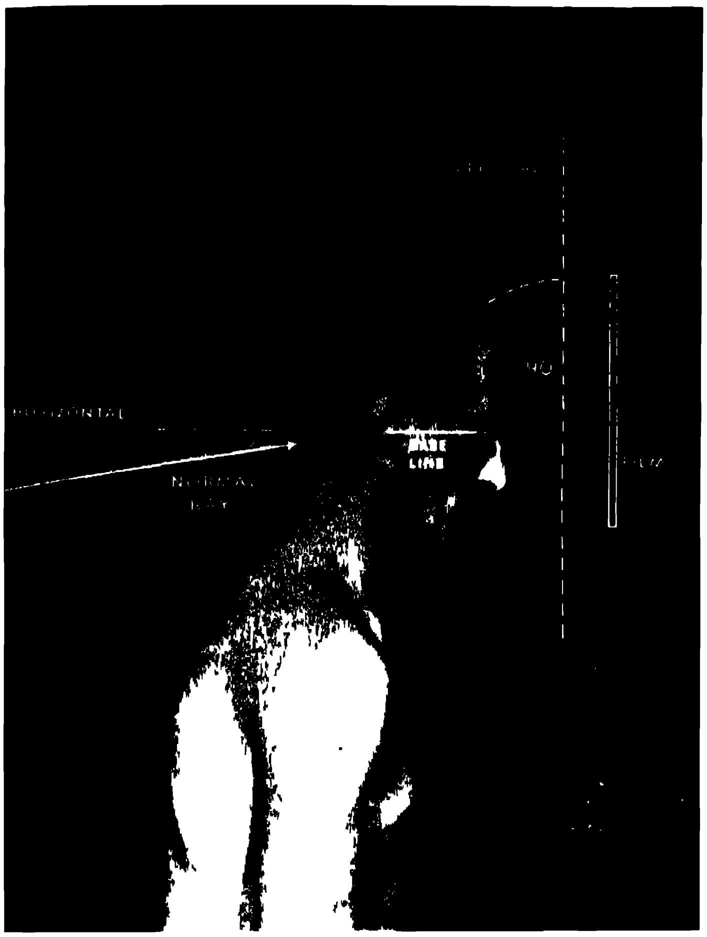
(642, 643, 644)

EXPOSURE FACTORS						
	mA Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	24″	Ilford	Tungstate	
65	40	24	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, $8\frac{1}{2}$ $6\frac{1}{2}$ in.

The dry skull illustration (**643**) is lined to show the method of positioning and centring to project the antra clear of the petrous temporals.

In the resulting radiograph (**644**) the antra are clearly shown beneath the dense base structures of the skull, with the anterior ethmoidal cells above and adjacent to the median line. The frontal sinuses are obscured in this view, and the orbits are overshadowed by the petrous temporals. The sphenoidal sinuses may be shown, with the clinoid processes of the sphenoid bone above them.



645

Air Sinuses of the Skull

10 DEGREES OCCIPITO-FRONTAL SHOWING MAXILLARY ANTRA, ETHMOIDAL AND SPHENOIDAL SINUSES

This is a repetition of the previous positioning of the patient, with a variation only in tube centring.

CENTRE to the nape of the neck, 2 inches below the occipital protuberance, with the tube angled 10 degrees toward the naso-frontal suture. The axial ray should be directed through the pituitary fossa and sphenoidal sinuses, the position of the fossa being estimated from the lateral aspect of the head and the tube adjustment being made with the aid of the sinus protractor.

(645, 646, 647)

EXPOSURE FACTORS

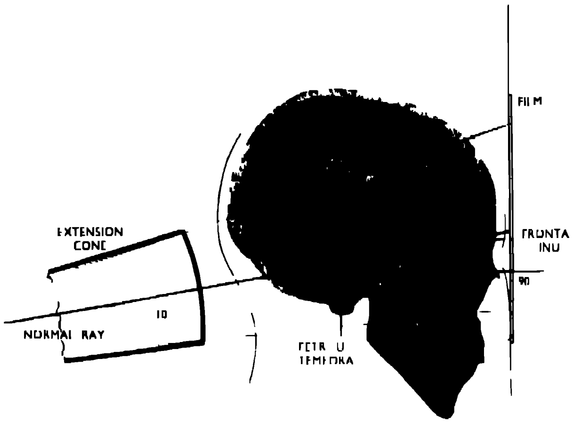
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	66	40	24″	Ilford	Tungstate	
65	40	24	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in.

The film is displaced toward the head to accommodate the tube angulation.

The sectional dry skull illustration (**646**) is lined to show the method of projecting the sphenoidal sinuses to overshadow the frontal bone, and should be compared with (**643**).

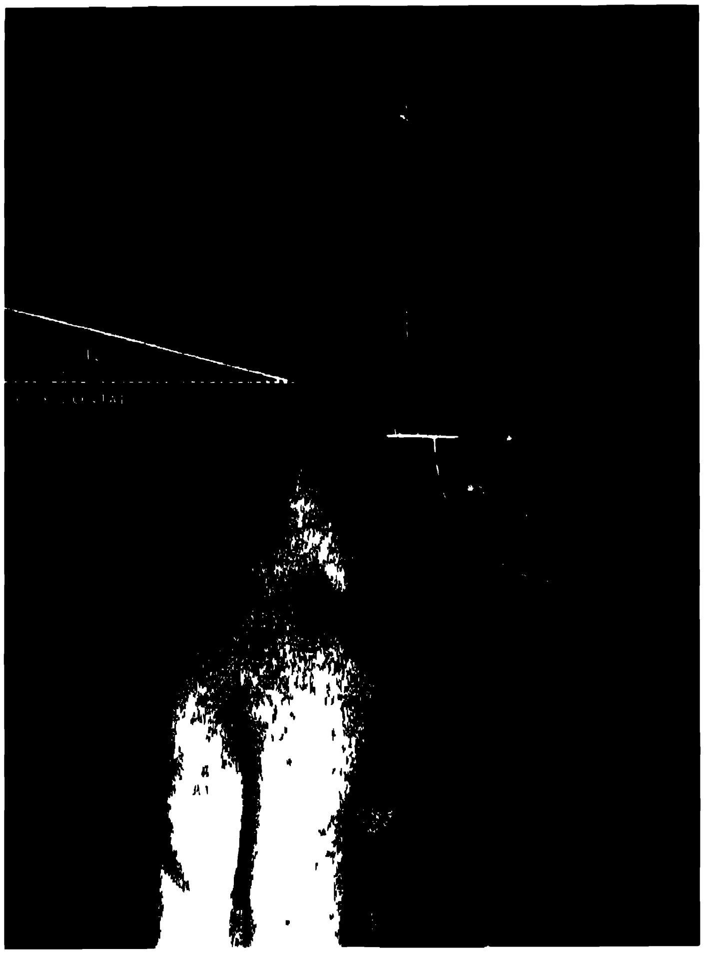
Comparison should be made of the resulting radiograph (**647**) and the previous radiograph (**644**), when the advantage of the tube angulation to show the sphenoidal sinuses will be appreciated.



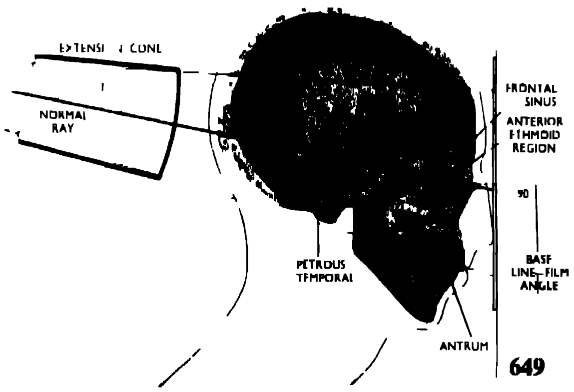
646

647

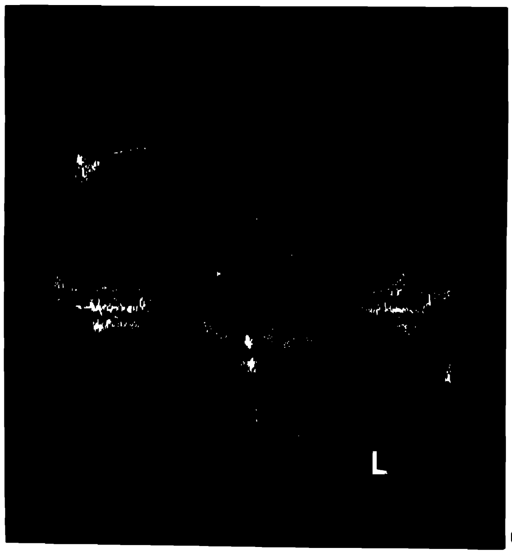
Air Sinuses of the Skull



648



649



650

10 DEGREES OCCIPITO-FRONTAL SHOWING FRONTAL AND ETHMOIDAL SINUSES

The patient is in the same position as for the two previous views, namely, with the base line at right angles to the film, with a variation only in tube centring and angulation.

The variation in centring is from *below* to *above* the base structures of the skull, so that the petrous temporals are projected below the orbits to overshadow the upper portions of the antra: this enables the frontal and ethmoidal air cells to be clearly demonstrated above the petrous temporals and without undue distortion, since the frontal region is in close proximity, and parallel, to the film, the small degree of tube angulation being negligible.

CENTRE from above the occipital protuberance, through the root of the nose, with the tube angled 10 degrees toward the feet.

(648, 649, 650)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	66	40	24″	Ilford	Tungstate	—
70	40	24	30″	Ilford	Tungstate	Potter-Bucky

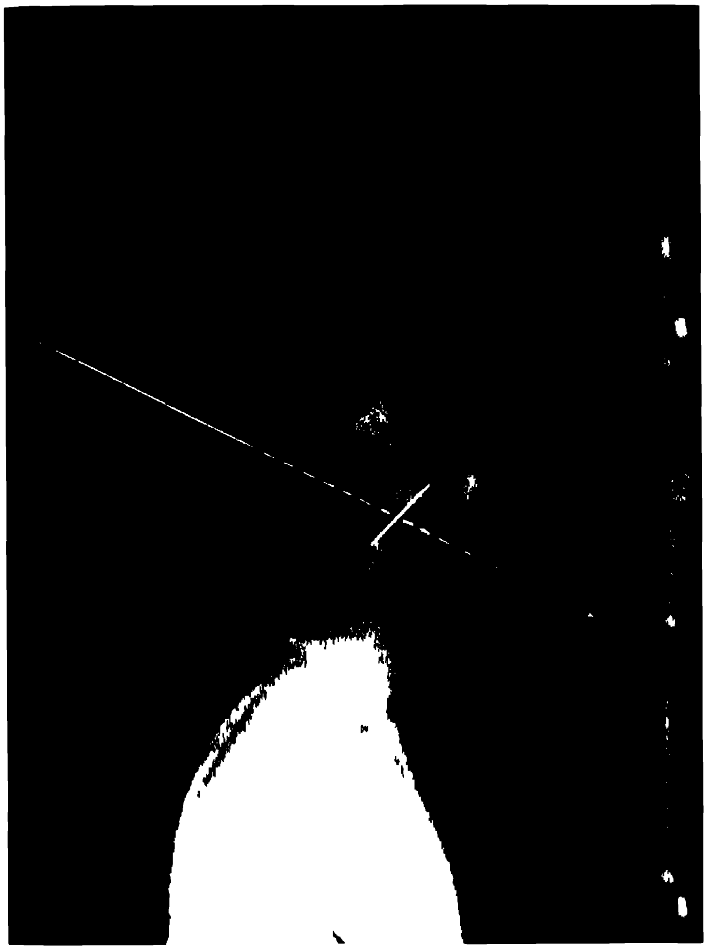
Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in.

The film is displaced toward the feet to coincide centrally with the axial ray.

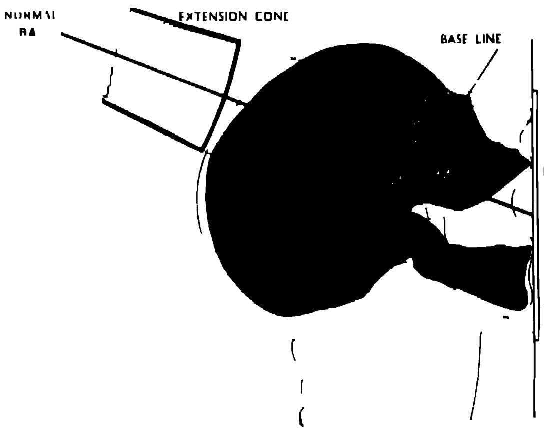
The sectional dry skull illustration (649) shows the method of projecting the petrous temporals in the desired relationship to the sinuses, and should be compared with (646).

The resulting radiograph (650) should be compared with (644) and (630).

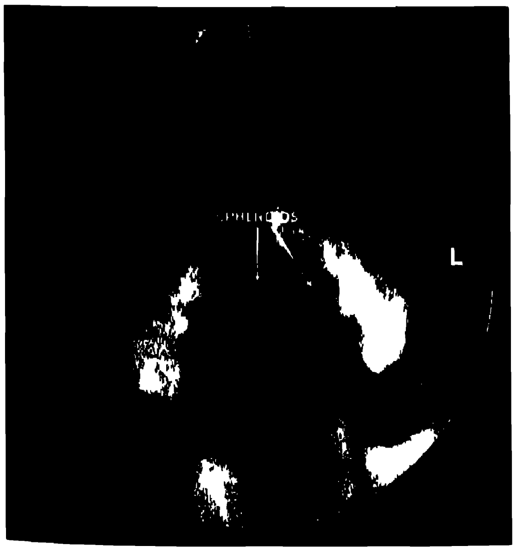
Air Sinuses of the Skull



651



652



653

VERTICO-MENTAL (OPEN MOUTH PROJECTION) SHOWING SPHENOIDAL SINUSES

The head is extended on the spine to bring the nose and chin into contact with the film support, the base line-film angle being adjusted to 45 degrees, as for the occipito-mental position. The jaws are separated by a 2½ inch cork or 3 inch bandage placed between the teeth.

CENTRE, with the tube angled 70 degrees to the base line, through the vertex of the skull, toward the open mouth and parallel to an imaginary line between the open mouth and one inch in front of the external auditory meatus, this latter being the antero-posterior level of the sphenoidal sinuses. As the space available for the image of the sinuses is bounded by the shadows of the upper and lower jaws, accurate centring is imperative.

(651, 652, 653)

EXPOSURE FACTORS						
	mA. Secs.					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
67	38	23	24″	Ilford	Tungstate	—
82	23	14	30″	Ilford	Tungstate	Potter-Bucky

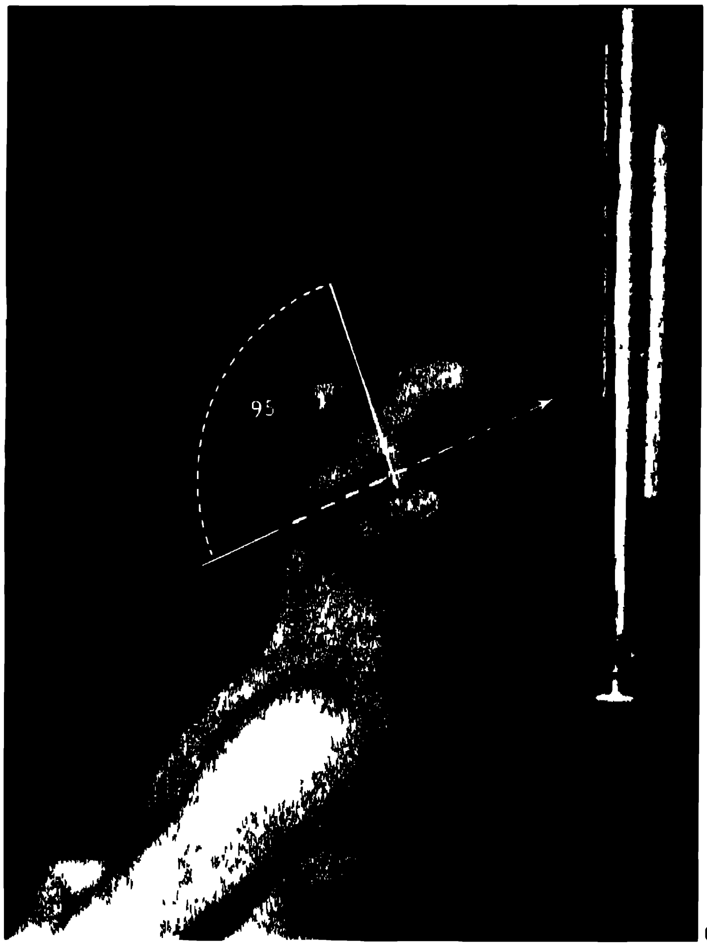
Cone to size of film, 8½ × 6½ in

The sectional dry skull diagram **(652)** shows the method of projecting the shadow of the sphenoidal sinuses between the open jaws.

This position is used when the subject is unable to maintain the following positions for demonstration of the sphenoidal sinuses.

Air Sinuses of the Skull

MENTO-VERTICAL—SHOWING SPHENOIDAL AND POSTERIOR ETHMOIDAL SINUSES



654

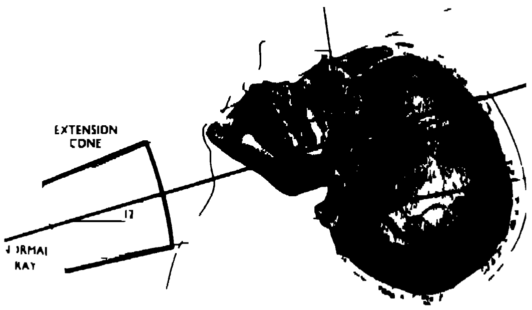
For this position the sinus stool is moved approximately twelve inches away from the film support and the patient is turned to face the tube. The neck is then extended and the trunk inclined backward to allow the vertex of the skull to make contact with the film support, the ideal position being reached when the base line and film are parallel, tube angulation being used, however, to compensate for inability of the subject to extend the neck. It is important that the patient should feel confident that no movement of the sliding stool can occur, and this may best be achieved by allowing the feet to be placed firmly on the floor, the stool having been locked in position.

CENTRE with the tube angled toward the head, in the median line, between the angles of the mandible and parallel to a line extending from the angle of the jaw to a point one inch in front of the external auditory meatus.

(654, 655, 656)

EXPOSURE FACTORS						
	mA Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
67	77	47	24″	Ilford	Tungstate	—
82	46	28	30″	Ilford	Tungstate	Potter-Bucky

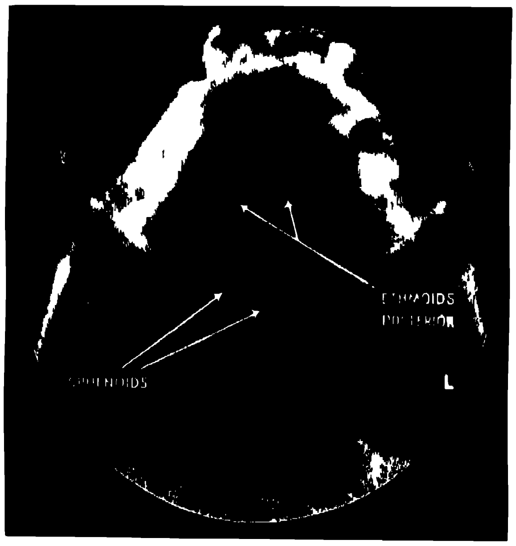
Cone to size of film, 8½ × 6½ in.



655

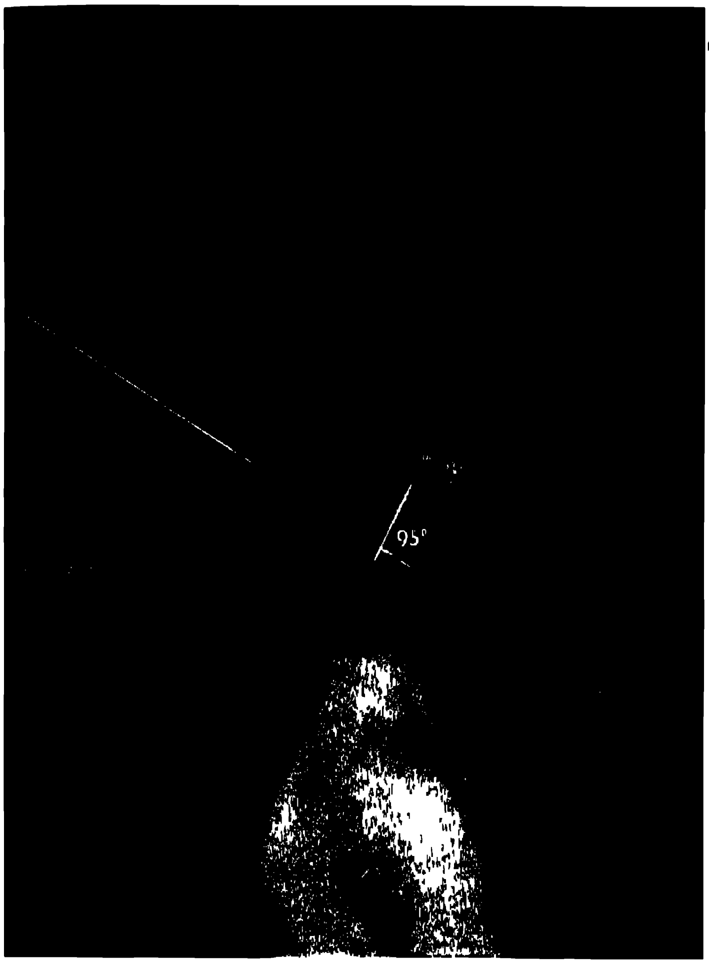
The film is displaced toward the head to coincide with the direction of the axial ray.

The mid-line section of the dry skull **(655)** is positioned and lined to show the method of projecting the sphenoidal and posterior ethmoidal cells clear of the jaws to overshadow the vertex of the skull.

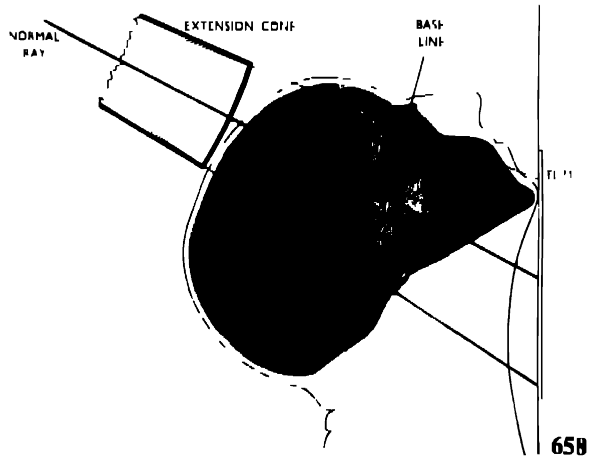


656

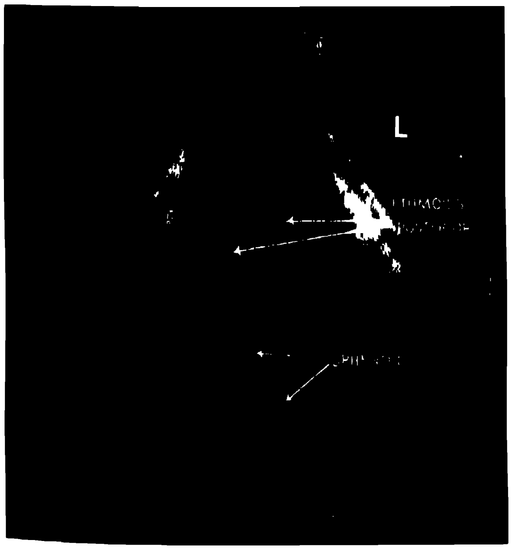
In this view **(656)** the sphenoidal sinuses are shown side by side in the mid-line of the structures forming the base of the skull, posteriorly being separated from the foramen magnum by the shadow of the naso-pharynx, with the posterior ethmoidal cells anteriorly within the curve of the mandible, these latter being sometimes partially obscured by the mandible.



657



658



659

Air Sinuses of the Skull

VERTICO-SUBMENTAL—SHOWING SPHENOIDAL AND POSTERIOR ETHMOIDAL SINUSES

This position is particularly suitable for patients with a long and flexible neck, but is somewhat difficult for the short-necked, high-shouldered type of subject.

The patient is seated facing the film, with the neck extended to bring the inferior border of the symphysis menti into contact with the film support. The base line-film angle should be less than 40 degrees.

CENTRE through the vertex, in the mid-line of the skull, parallel to a line between the angle of the jaw and one inch in front of the external auditory meatus: this will be approximately at 95 degrees to the base line. The inclination of the tube in relation to the horizontal varies from 30 degrees to 40 degrees, according to the flexibility of the subject.

(657, 658, 659)

EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
67	77	47	24″	Ilford	Tungstate	
82	46	28	30″	Ilford	Tungstate	Potter-Bucky

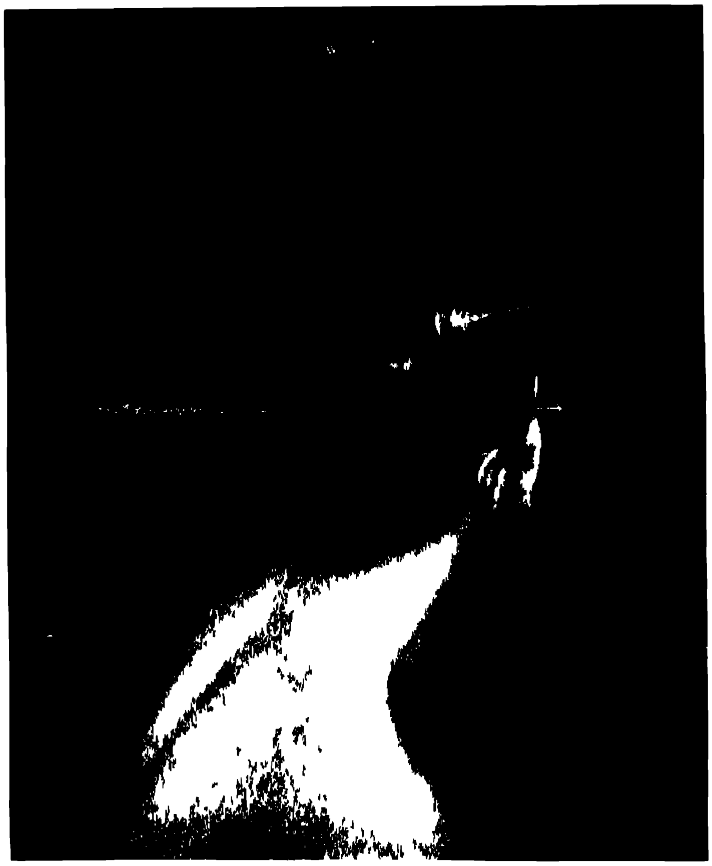
Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in.

The film is displaced toward the feet to accommodate the axial ray.

The dry skull (**658**) is positioned and lined to show the principle of this projection, and, this being the reverse of the previous view, should be compared with (**655**).

The resulting film (**659**) is similar to (**656**), but unless careful positioning and centring are applied there is a tendency for the posterior ethmoidal cells to be partially or wholly obscured by the mandible owing to its close proximity to the film.

660



661

OBLIQUE—RIGHT AND LEFT—SHOWING POSTERIOR ETHMOIDAL SINUSES AND OPTIC FORAMINA

The head is placed with the nose and forehead toward the film, and the head clamp is applied to the bi-temporal diameter of the cranium. From this position the head is rotated through 35 degrees to 40 degrees to right and left sides in turn, and the chin then allowed to make contact with the film support so that the base line is at an angle of 30 degrees, and the side of the face being examined—nose, eyebrow, zygomatic bone and chin—is parallel, to the film. It should be noted that the correct position is more readily obtained when commencing with the nose-*forehead* rather than with the nose-*chin* position.

CENTRE $2\frac{1}{2}$ inches above and behind the opposite external auditory meatus, directly through the orbit proximal to the film.

(660, 661, 662, 663, 664)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
52	66	40	24″	Ilford	Tungstate	—
67	40	24	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in.

The horizontal end-on view (**662**) is included to show the rotation of the head.

NOTE—The resulting radiographs show the shadows of the posterior ethmoidal cells obscuring the region from the lower two-thirds of the orbit to the roots of the upper teeth. It is essential for both sides to be similar, this being checked by noting the symmetrical position of the optic foramina appearing within the shadows of the orbits.

OPTIC FORAMINA

These show as small circular shadows within the orbits, and when they are specially asked for the above described oblique views are taken to demonstrate them.

662

663

664

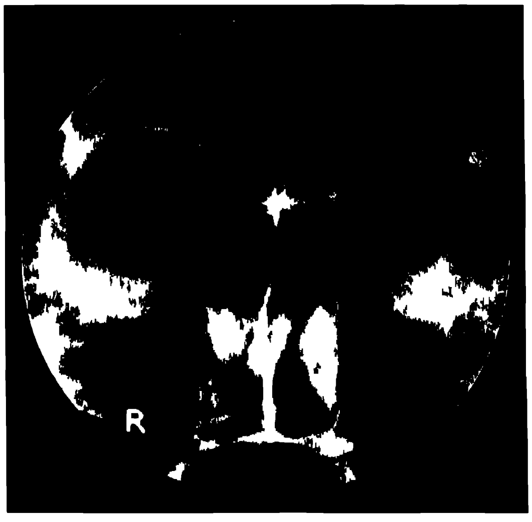
No.	Position	Adjustment	Centring	Tube Angle	Sinuses Shown
665	Occipito-Frontal	Base Line 90°	1½″ below Occiput	Nil	Antra—Ant. Ethmoidal
666	Occipito-Frontal	Base Line 90°	2″ below Occiput	10° Frontal	Antra—Sphenoidal
667	Occipito-Frontal	Base Line 90	2″ above Occiput	10° Mental	Frontal—Ant. Ethmoidal
668	Occipito-Mental	Base Line 45	1½″ above Occiput	Nil	Frontal—Antra
669	Occipito-Mental	Base Line 45	2″ above Occiput	10 Mental	Antra—Frontal
670	Occipito-Mental (head bent)	Base Line 45	2″ above Occiput	Nil or 10° Mental	Antra—Frontal

665

668

666

669

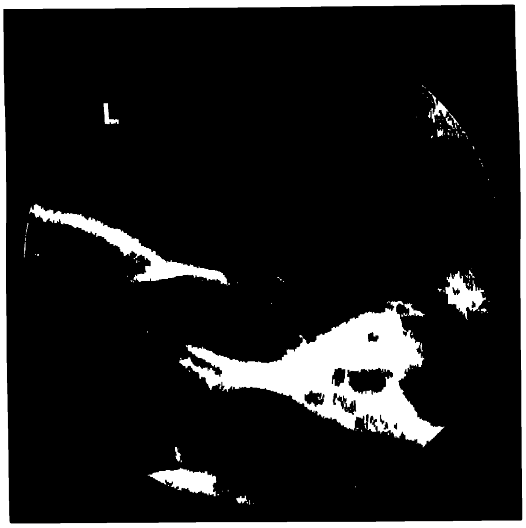


667

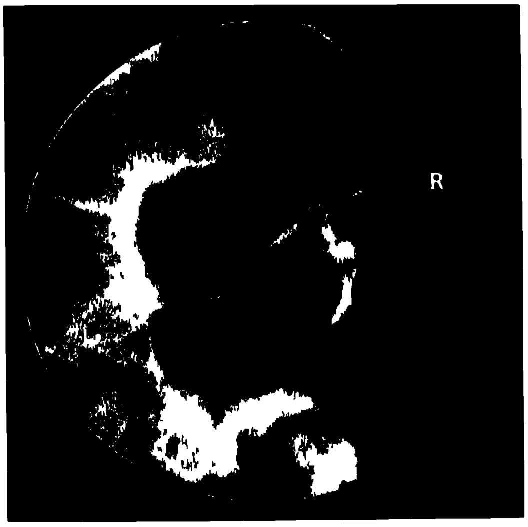
670

No.	Position	Adjustment	Centring	Tube Angle	Sinuses Shown
671	Lateral	Interorbital Line 90°	1″ from eye along Base Line	Nil (unless compensatory)	All Sinuses
672	Lateral	Interorbital Line 90°	1″ in front and above E.A.M.	Nil (unless compensatory)	Sphenoidal
673	Oblique (R. and L.)	Base Line 30°	2½″ above and behind E.A.M.	Nil	Posterior Ethmoidal Optic Foramina
674	Vertico-Mental	Base Line 45	Vertex to open mouth	70	Sphenoidal
675	Mento-Vertical	Base Line parallel	Median Line between angles of jaw	95 to Base Line	Sphenoidal. Post. Ethmoidal
676	Vertico-Submental	Not less than 40	Vertex	95 to Base Line	Sphenoidal. Post. Ethmoidal

671



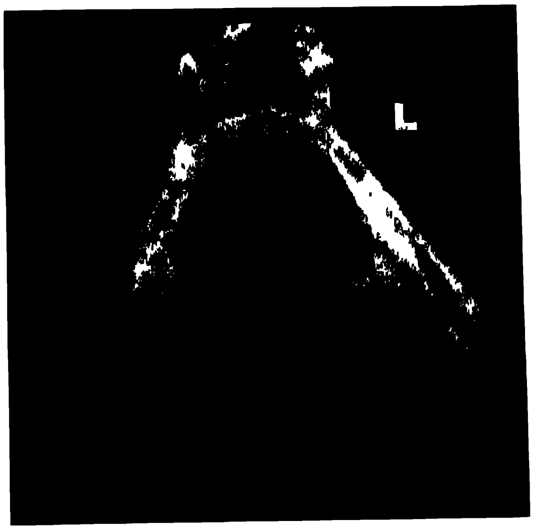
672



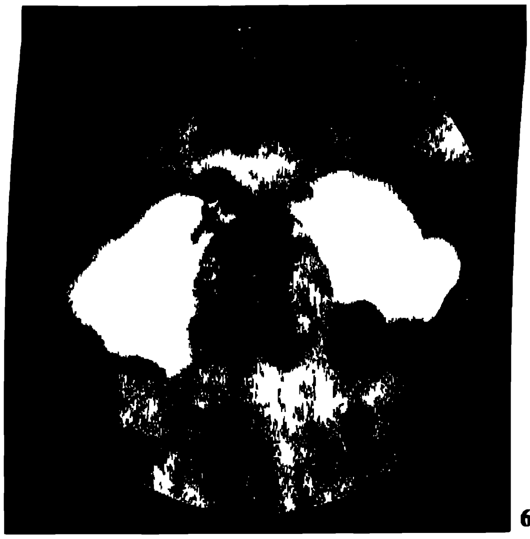
673

674

675



676


677

678

OPAQUE INJECTIONS

It is only on rare occasions that iodised oil is injected into the sinuses, and then it is chiefly the antra which are so examined. Each side is usually injected separately, so that the complete X-ray examination may be carried out on right or left side without, in the lateral view, superimposition of the opposite side (678).

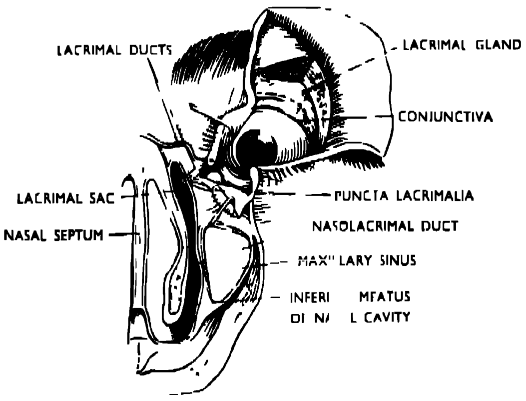
When a large aperture is present, following an operation, it is essential to carry out the examination in the horizontal position, otherwise routine vertical views are taken.

The whole of the antrum is outlined: it is clearly shown in the postero-anterior position in both the occipito-frontal and occipito-mental views (677), and also in the lateral view (678), the posterior border here being well defined.

SECTION 13

Lacrimal Ducts

LACRIMAL DUCTS



THE LEFT LACRIMAL APPARATUS

679

680

680a

The lacrimal apparatus of each eye consists of the lacrimal gland, which secretes the tears, and the lacrimal ducts, lacrimal sac and naso-lacrimal duct, through which the tears pass from the eye into the nasal cavity.

The lacrimal gland is found in the upper and outer part of the orbital cavity, and the lacrimal ducts commence at the inner canthus of the eye, one in each lid, as minute orifices, named puncta lacrimalia. Approximately 10 millimetres long, each lacrimal duct terminates at its opening into a lacrimal sac, a small reservoir situated in the lacrimal fossa, which last is formed by the lacrimal bone and the frontal process of the maxilla. This sac, 12 millimetres in length, discharges, in turn, into the naso-lacrimal duct, a channel some 18 millimetres in length which opens into the nose **(679)**.

These lacrimal passages from the eye to the nose are examined radiographically in order to confirm or refute the presence of an obstruction, an opaque medium, such as iodised oil, being injected, usually into the lower puncta.

The injection is given with the patient on the X-ray couch. A local anæsthetic is employed to render the conjunctiva insensitive; the duct in the lower eyelid is then dilated to allow the entrance of the lacrimal needle, which has a bulbous tip. From 1·5 to 2 cubic centimetres of iodised oil are injected, the oil being used at body temperature.

A series of films is exposed in two positions, occipito-mental and lateral, as follows:—

(1) preliminary, before the injection:
(2) while the last few drops of oil are being injected:
(3) five minutes after the injection:
(4) ten minutes after the injection.

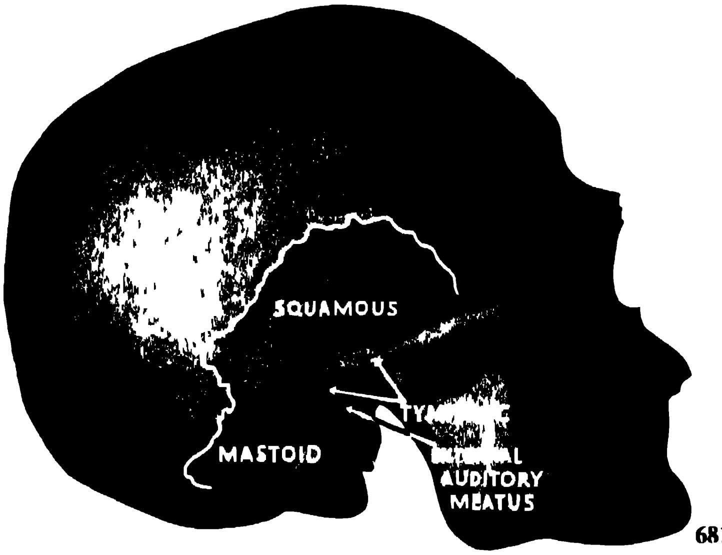
In normal subjects the maximum shadow is seen in the immediate films; in the five-minutes films the iodised oil is seen passing to the nasal cavity; while at ten minutes there is very little sign of the injection having been given.

Of the accompanying two films, taken after the injection, **(680)** shows, medially, the ducts leading, one each, from the upper and lower lids, and the lacrimal sac; and in **(680a)** the iodised oil is seen passing through to the nasal cavity.

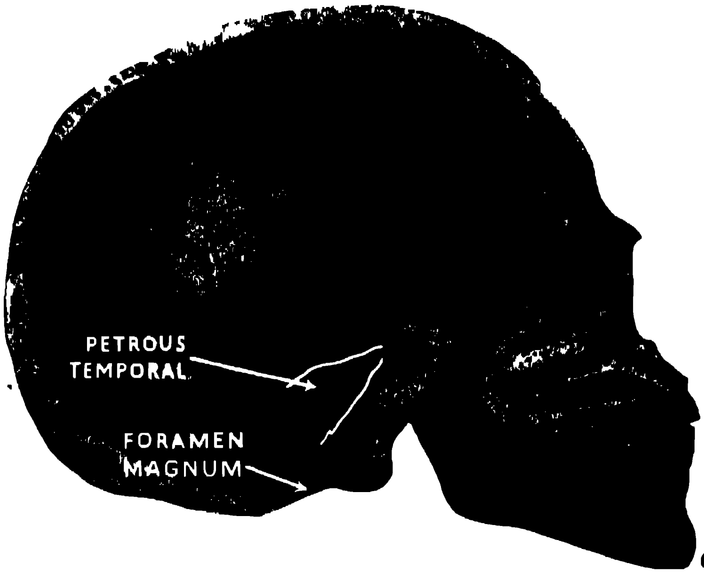
In positioning the patient it is important to remember that an undistorted view of the orbits is required, and the base-line-film angle can well be reduced from 45 degrees to 40 degrees; otherwise the positioning technique and exposure factors are similar to those given on pages 228 and 231 for the air sinuses of the skull. The accompanying films were taken with the patient in the horizontal position.

SECTION 14

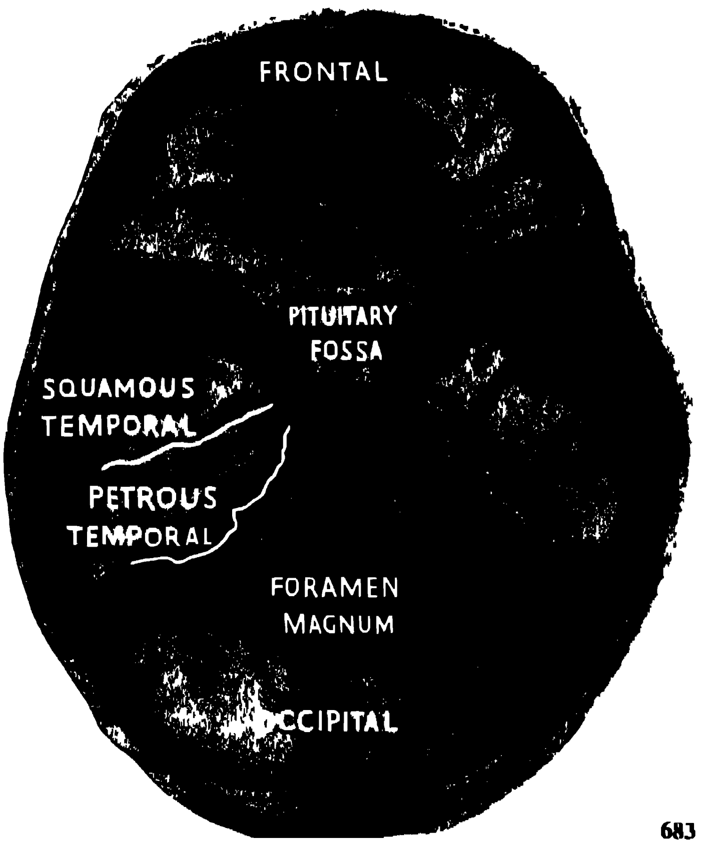
Temporal Bones



681



682



683

SECTION 14

TEMPORAL BONES

ANATOMICAL POSITION AND STRUCTURE

The temporal bones form part of the lateral aspects and floor of the cranium, as shown in the dried skull illustrations. Each consists of squamous, mastoid, petrous and tympanic portions and styloid process. Of these this section deals chiefly with the mastoid and petrous portions, and only brief reference is made to the remainder of the temporal bone.

(681, 682, 683)

The *squamous* portion is a flat area of thin bone situated above, in front of and behind the ear.

The *tympanic* portion forms the antero-inferior part of the external auditory canal and enters into the mandibular fossa.

The *styloid* process is long and slender, and projects downward toward the angle of the jaw.

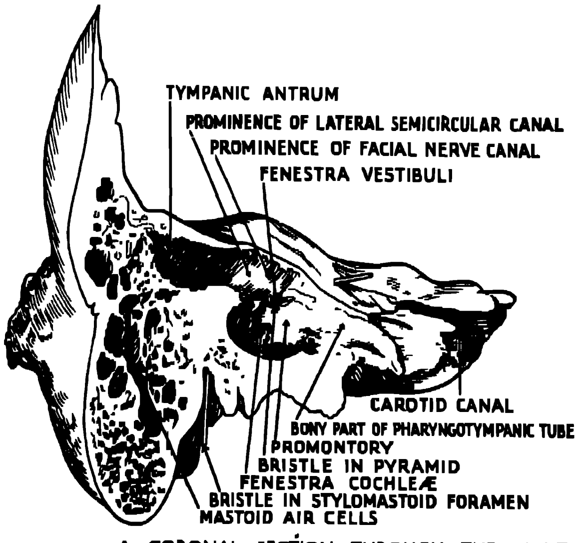
The *mastoid* portion, behind the ear, contains the mastoid (or tympanic) antrum and the mastoid air cells, which vary in shape, number and size from subject to subject **(684)**.

The *petrous* portion, or pyramid, is the most complex part of the temporal bone, being wedged between the sphenoid and occipital bones in the base of the cranium, and containing the essential parts of the organs of hearing and equilibrium. There are two distinct parts, the tympanic cavity, or *middle ear*, and the labyrinth, or *internal ear*.

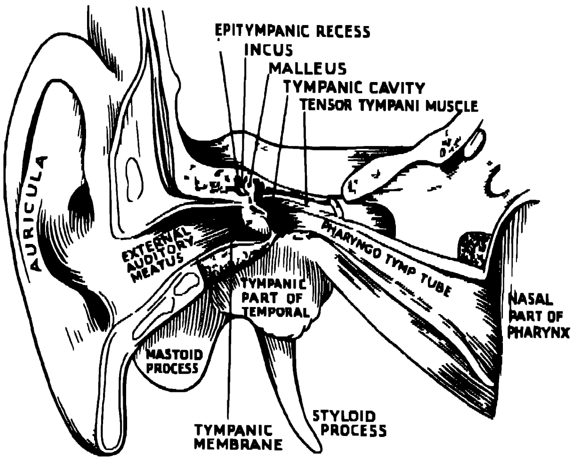
The tympanic membrane separates the *external ear* from the tympanic cavity, or *middle ear* **(685)**. A chain of fragile bones, named the malleus, the incus, and the stapes, connects the tympanic membrane with the inner wall of the tympanic cavity, bridging the cavity and transmitting to the *internal ear* vibrations received from the *external ear*, by the tympanic membrane.

The internal ear, or labyrinth **(686)**, consists of a series of bony cavities, named the vestibule, the semicircular canals, and the cochlea; contained within the labyrinth is a similarly shaped membranous vessel. Diagram **(685)** shows a vertical section through the temporal bone.

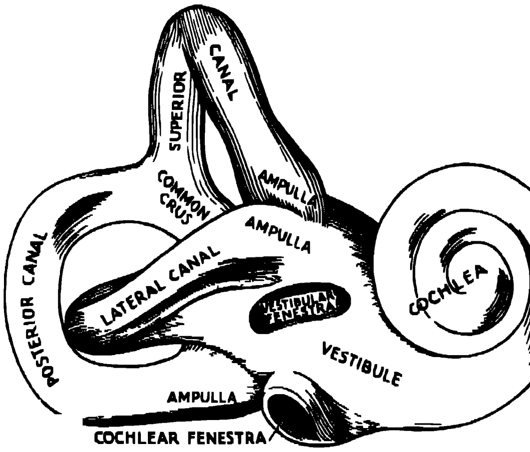
(684, 685, 686)



A CORONAL SECTION THROUGH THE RIGHT TEMPORAL BONE ANTERIOR ASPECT 684



THE EXTERNAL AND MIDDLE PORTIONS OF THE RIGHT EAR FROM THE FRONT 685



THE RIGHT OSSEOUS LABYRINTH LATERAL ASPECT 686

Temporal Bones: Mastoid

TECHNIQUE

The technique for the examination of the temporal bone is given under two headings, namely, mastoid and petrous.

For each part the operator is advised to examine the dried skull and to make experimental exposures from various aspects until assured as to the positioning required for routine exposures on the patient.

Radiographic investigation is concerned with demonstrating the various cavities and their contents, the cavities being so small and delicately placed within the temporal bone that only the most exacting positioning technique and the finest film definition can demonstrate this region successfully.

To obtain the necessary definition a fine focus tube is essential, the result being improved by the use of fine-grain intensifying screens and a small localising cone. Films may be taken either with or without the grid, and the patient may be examined in either the erect or the horizontal position. *Both sides are always taken for comparison.*

IMPORTANT.—Each film should be carefully marked as to right and left, using small quarter-inch lead letters.

Mastoid

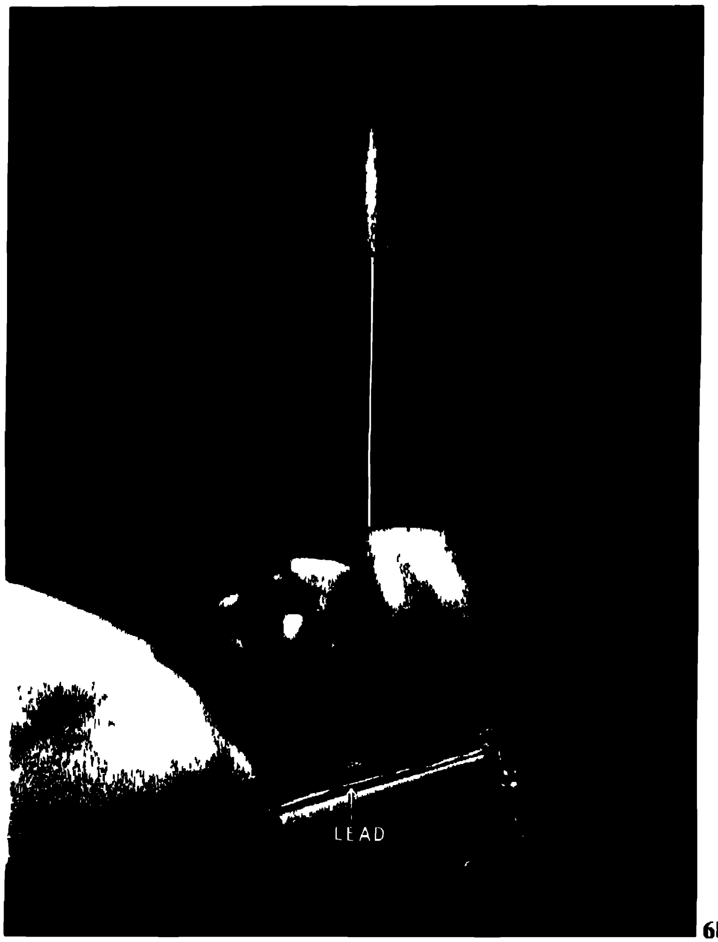
The mastoids occupy accessible, mid-lateral positions behind the ears, as seen from the lateral aspect of the skull (**681**). In the true lateral position they coincide, and it is necessary to take oblique views in order to obtain separation of the two shadows in much the same way as for the examination of the temporo-mandibular articulations.

The mastoid process in profile usually presents the greater difficulty. It is necessary to project the process clear of the cervical spine by rotating the head on its axis and at the same time downward slightly so as to project the mastoid tip below the shadow of the occipital bone.

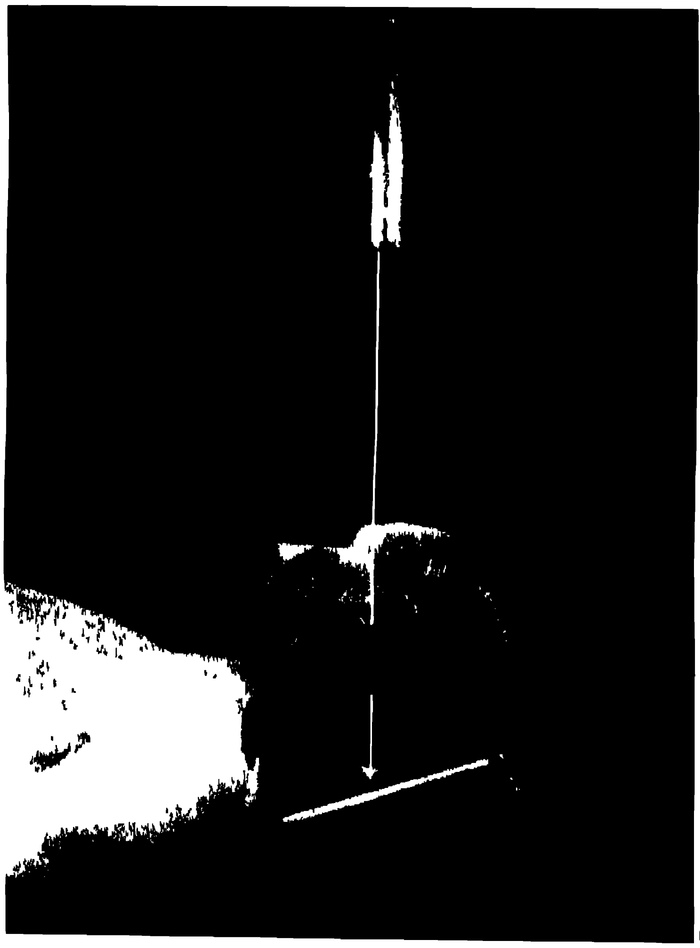
Films may be taken from either antero-posterior or postero-anterior aspect, with or without the angle board and grid. Both sides are always taken for comparison. With modern mastoid apparatus the exact duplication of the two sides is a simple achievement, but not all radiographers have such accessories at their disposal.

It is imperative that the walls of the cells should be sharply defined, and that there should also be adequate contrast between actual air cells and walls.

The exposure factors quoted in the text refer to an adult subject of average size.



687


688

Temporal Bones: Mastoid

PROFILE

In these views the less dense mastoid process is projected clear of the shadows of the base of the skull, the denser shadow of the mastoid antrum appearing in the same film. In order to demonstrate both densities satisfactorily it is necessary to compromise in applying the exposure factors. A kilovoltage suitable for the antrum is selected: this should be sufficiently high to reduce the contrast between the two bone densities so that both antrum and tip are equally well shown. A lower kilovoltage, although producing brilliant intimate contrast in the mastoid process, allows either under-exposure of the antrum or over-exposure of the tip, thus necessitating a local chemical reduction in density.

(1) ANGLE BOARD—ANTERO-POSTERIOR OBLIQUE

With the patient supine, the head is placed in contact with the cassette on the 15 degrees to 25 degrees variable angle board, the frontal plane of the head being parallel to the film from forehead to chin. From this position the head is turned through an angle of 35 degrees away from the affected side, the chin being kept well down toward the chest. An examination of the head in this position shows the mastoid process in direct alignment with the film and without overshadowing by adjacent bone structure (**688**).

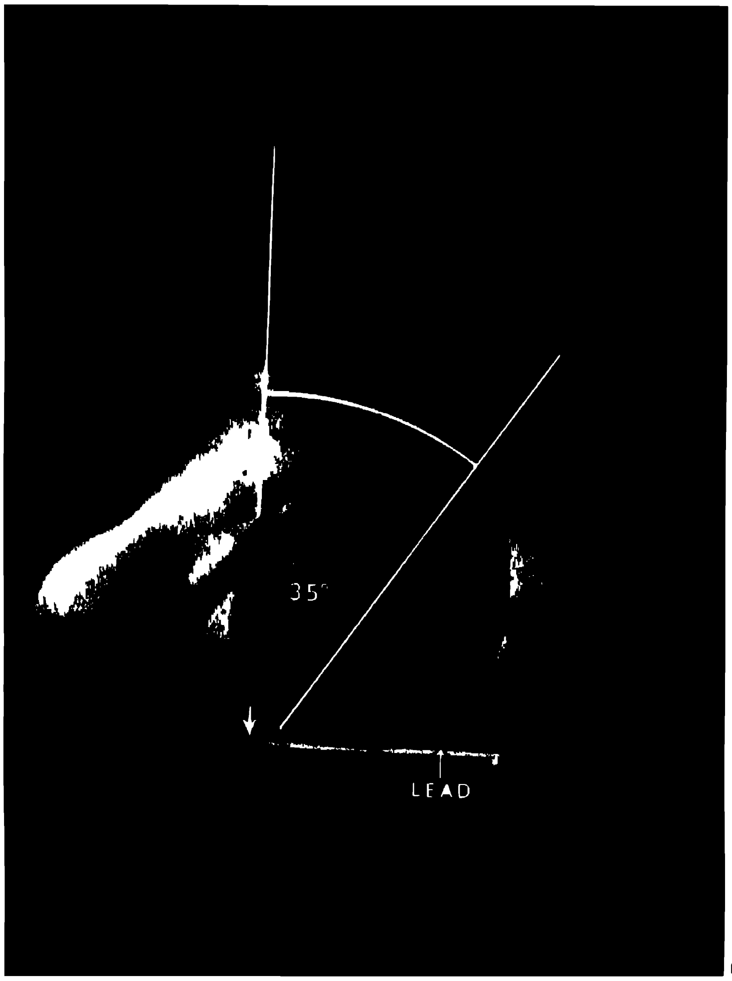
The two sides may be taken on a single film by covering alternate halves with lead as shown in the illustration, or two small films may be used.

CENTRE over the root of the mastoid process remote from the film. A small localising cone is essential (**687, 688, 689, 690, 691**).

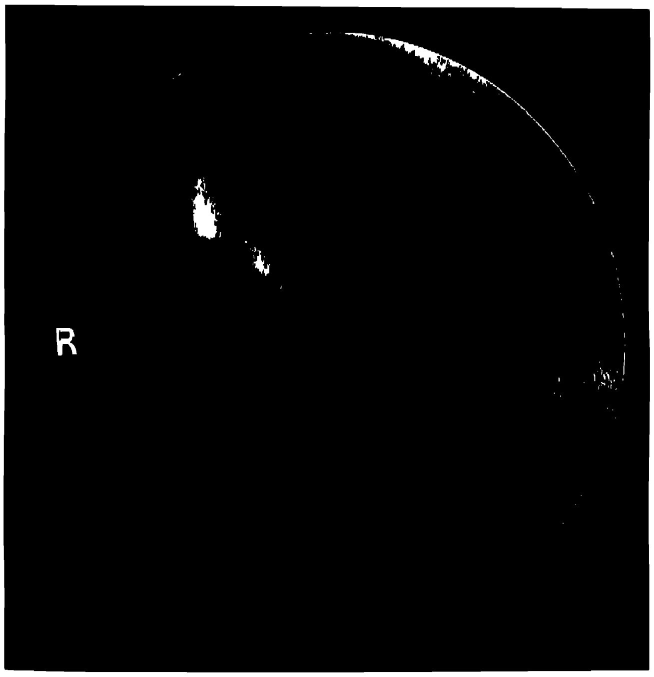
EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	23	14	28″	Ilford	Tungstate	—

Small cone: size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in. or $8\frac{1}{2} \times 6\frac{1}{2}$ in.

In the resulting radiographs (**690, 691**) the mastoid tip and antrum are clearly demonstrated. This position is easily obtained and should be within the scope of all workers. The angle board may be replaced by a solid angle block similar to that illustrated on page 201, Section 10, or by suitably placed sandbags.

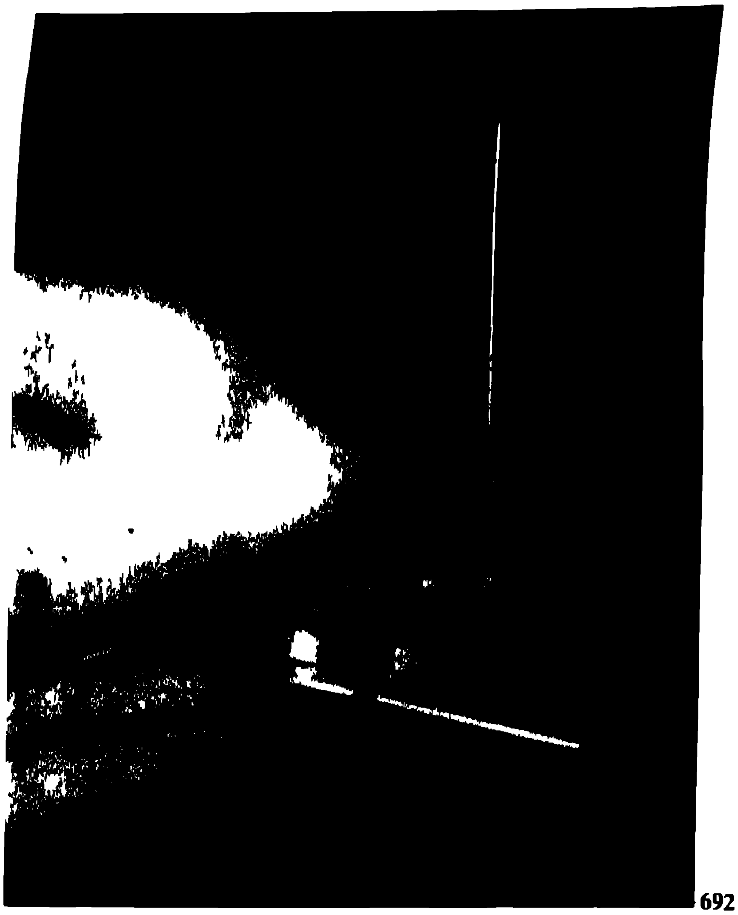


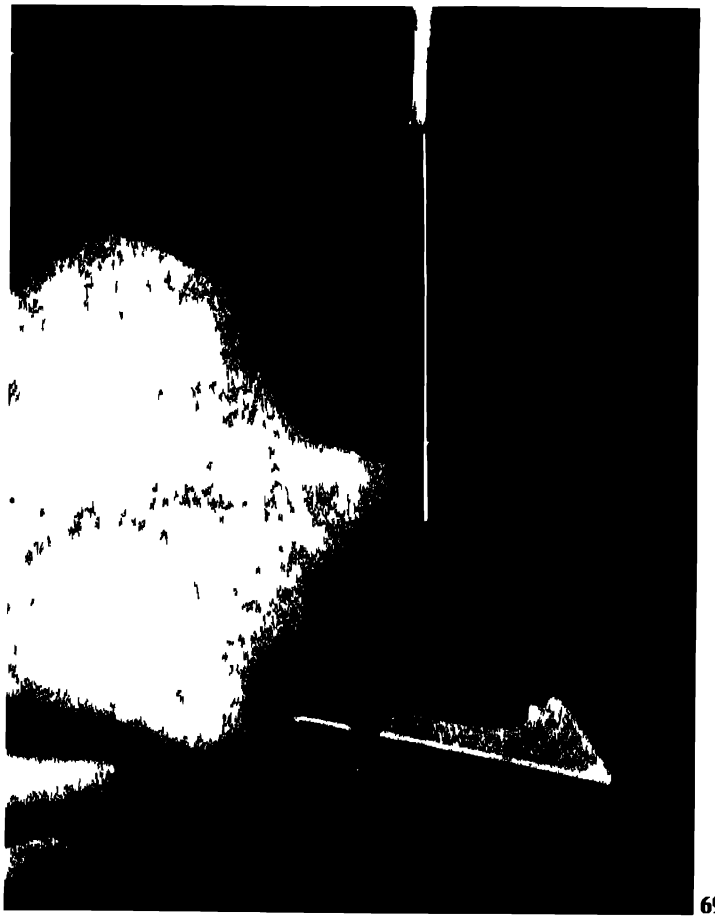
689



690

691


692


693

PROFILE (1)—ANGLE BOARD ANTERO-POSTERIOR OBLIQUE *(continued)*

The angle of the angle board should be varied according to type of subject A patient with thin shoulders and a long neck will allow comfortable adjustment of the head at a 15 degrees angle, but for a thick shouldered subject, with a short neck, an angle of 25 degrees is essential.

PROFILE (2)—ANGLE BOARD POSTERO-ANTERIOR OBLIQUE

In this position both patient and angle board are reversed as compared with the previous technique, the patient being placed to face the film instead of facing the tube, with the angle board opening toward the neck instead of toward the head In this position the patient may be seated, when required, instead of being at full length on the couch

The head is flexed laterally over the 15 degrees to 25 degrees angle board, placed with the open end toward the neck, and is then turned through 55 degrees toward right and left in turn, the side for exposure being nearest to the film, with the cheek, eyebrow and nose in contact with the cassette The chin is raised on a $1\frac{1}{2}$ inch cork support

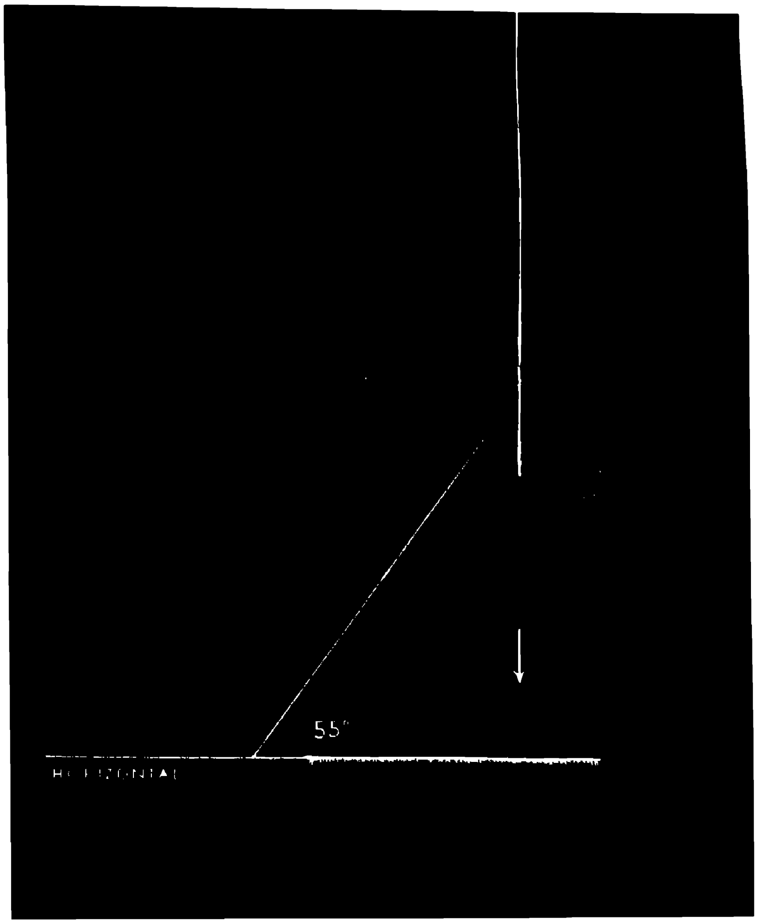
CENTRE over the mastoid process nearest the film, using a small localising cone

(692, 693, 694, 695, 696)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford Developers X-ray	Blue Label	Distance	Film	Screens Ilford	Grid
60	23	14	28″	Ilford	Tungstate	—

Small cone size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in or $8\frac{1}{2} \times 6\frac{1}{2}$ in

The view shown in the resulting radiographs **(695, 696)** is similar to that shown in the previous pair **(690, 691)**



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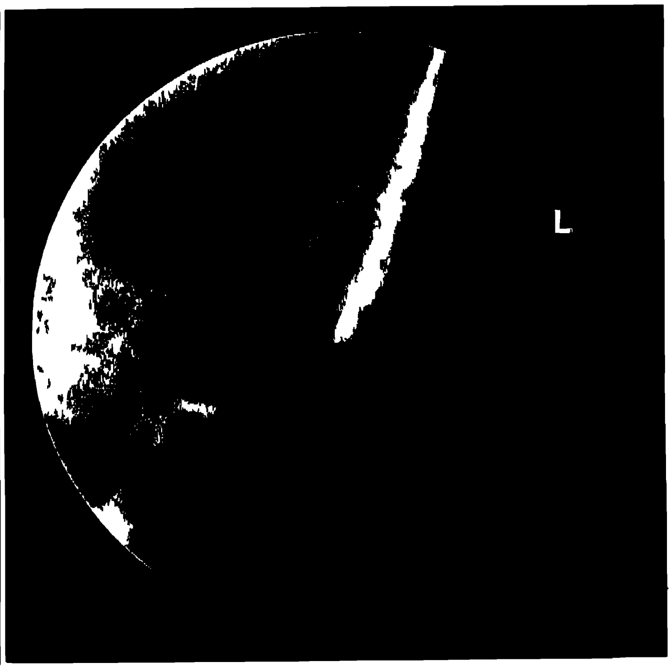
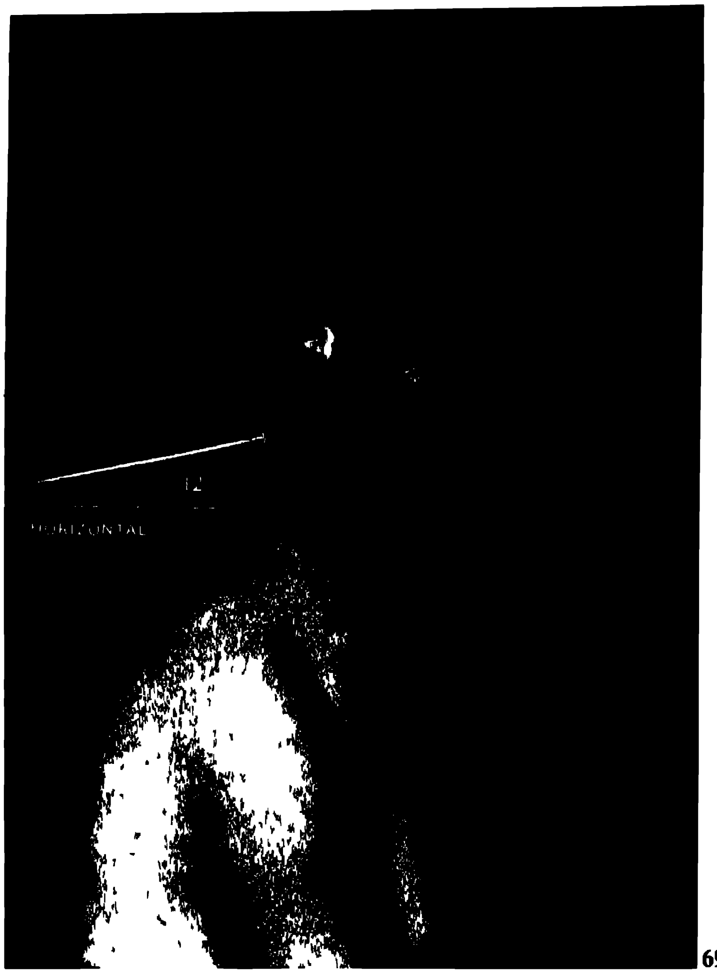
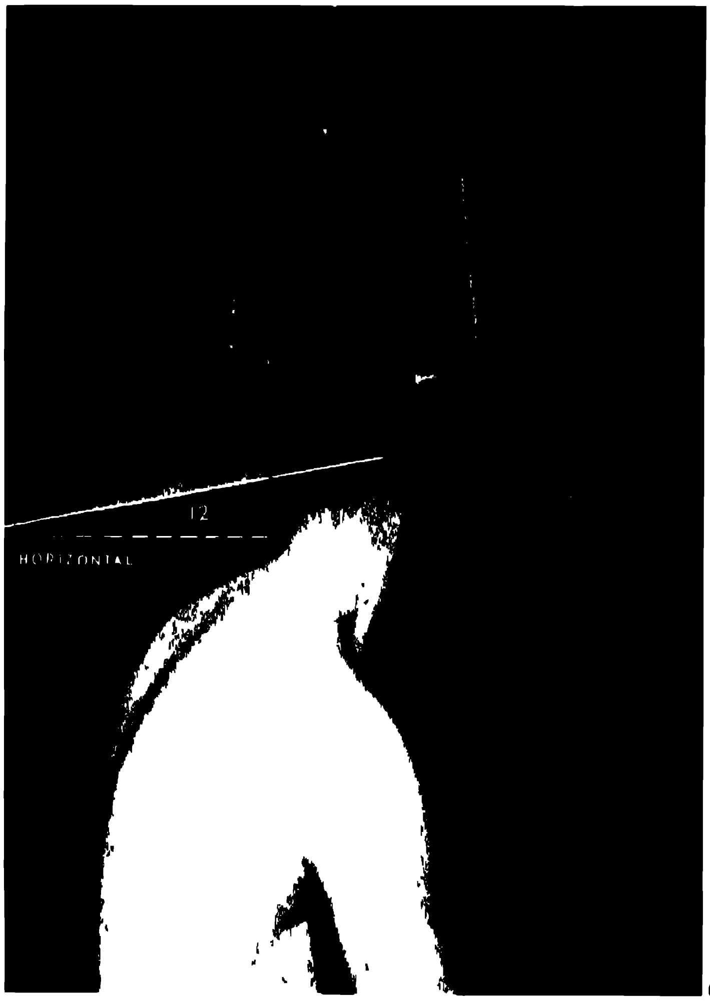
695



696



697



698

Temporal Bones: Mastoid

PROFILE (3)— POSTERO-ANTERIOR OBLIQUE

This view may be taken with the patient in either the erect or the horizontal position, the Potter-Bucky diaphragm being usually employed.

The head is placed in the occipito-frontal position, with the head clamp applied to the bi-temporal diameter, and then turned through 35 degrees toward the affected side, the base line film angle being adjusted to 85 degrees. In the horizontal position correct angulation is obtained by applying the protractor to the head from the end of the couch (700).

CENTRE mid-way between the occipital protuberance and the external auditory meatus of the side nearest the film, with the tube angled 12 degrees toward the head.

(697, 698, 699, 700, 701, 702)

EXPOSURE FACTORS

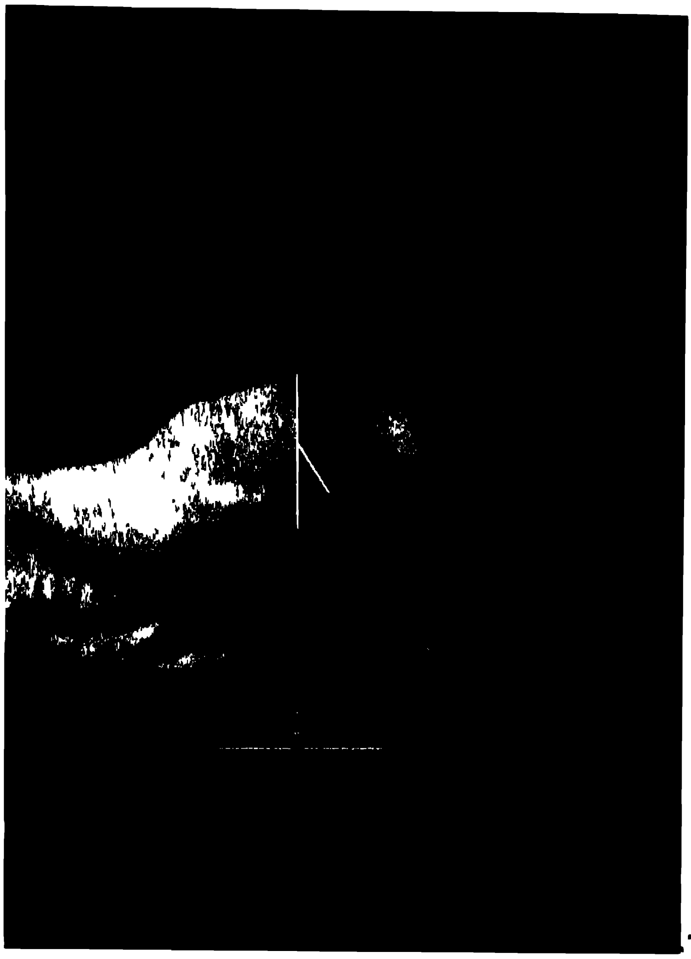
kVp	mA	Secs	Distance	Film	Screens	Grid
	Ilford X-ray	Developers Blue Label			Ilford	
70	53	32	30″	Ilford	Tungstate	Potter-Bucky

Small cone size of film, $8\frac{1}{2} \times 6\frac{1}{2}$ in

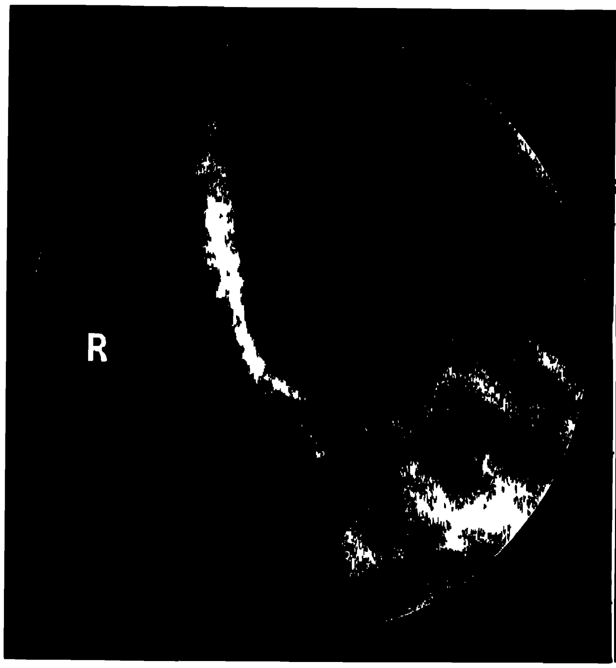
On examining the head in this position it will be seen that from the tube aspect the mastoid process is in profile and free from overshadowing structures, as also in the previous positions with the angle board.

Comparison for similarity should be made of the three pairs of films taken to show the mastoid process in profile. In radiographs (701) and (702) the clear demonstration of the temporo-mandibular joints should be noted.

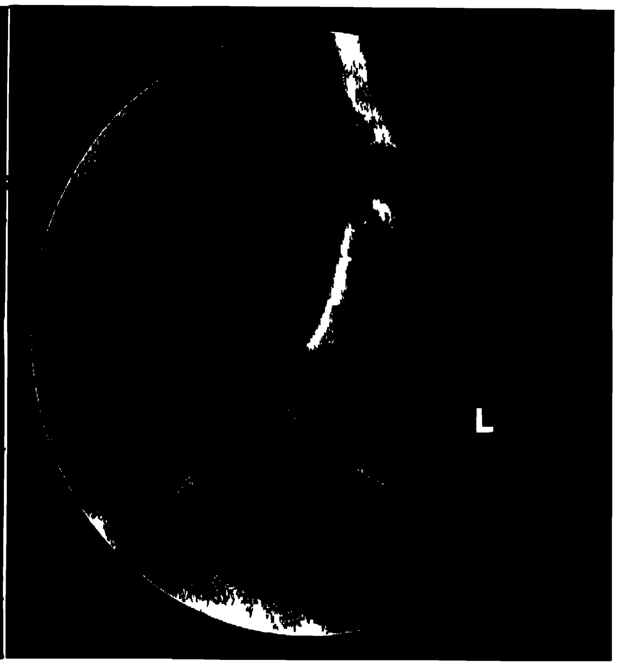
699



700

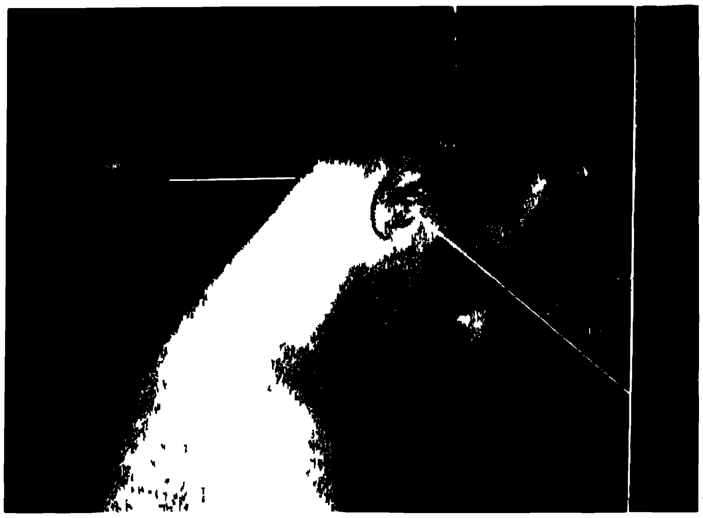


701



702

Temporal Bones: Mastoid



703

OCCIPITO-VERTICAL

With the patient facing the film, the head is flexed forward, with the chin well down on the chest to bring the vertex of the skull into contact with the film support. The base line to film angle should be approximately 50 degrees.

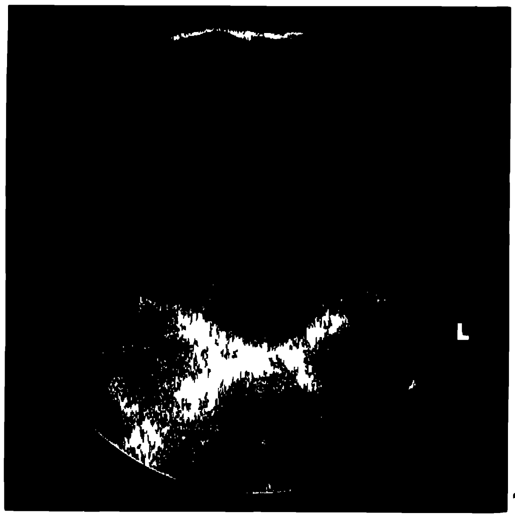
CENTRE midway between the roots of the mastoid processes.

(703, 704)

EXPOSURE FACTORS						
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	82	50	44″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in

In the resulting radiograph both mastoid regions are shown, following a single exposure.



704

35 DEGREES FRONTO-OCCIPITAL

The patient is placed facing the tube, with the chin well down on the chest and with the occipito-cervical region in contact with the film support.

CENTRE in the median line between the mastoid processes, with the tube angled 30 degrees to 40 degrees toward the feet

(705, 706)

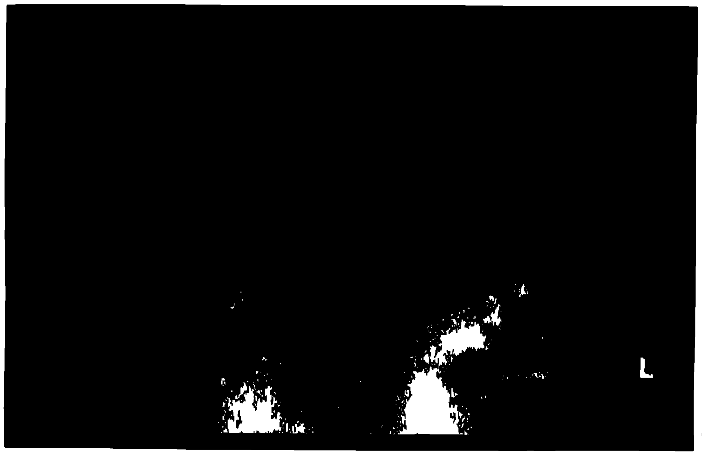
705

EXPOSURE FACTORS						
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	82	50	44″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in

In this view also a single exposure shows both mastoids symmetrically on the same film.

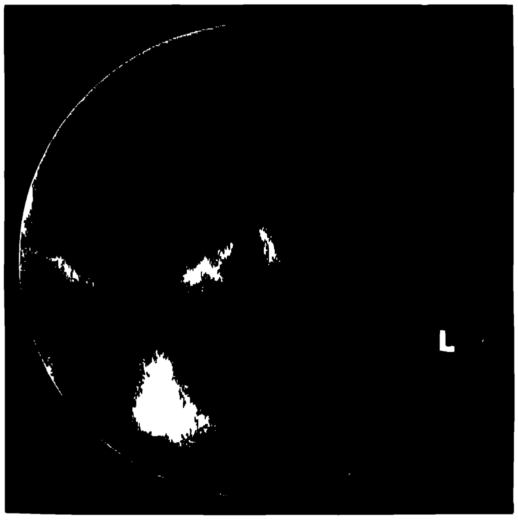
In both views shown on this page the patient may be examined in either the erect or the horizontal position.



706

707

708



709

710

Temporal Bones: Mastoid

LATERAL OBLIQUE

For the lateral view it is necessary to obtain separation of the two sides either by tilting the head or by angling the tube in relation to the head. The auricle of the ear proximal to the film is folded forward (707) to enable the maximum definition to be obtained, and the air cells are shown superimposed on the cranial bones.

(1) HEAD TILTED

From the lateral position the head is allowed to tilt forward and downward to assume a naturally comfortable position, with the chin and cheek in contact with the film support, the auricle of the ear being folded forward to avoid obscuring the mastoid cells. This position allows the two sides to be well separated from the tube to film aspect.

CENTRE two inches above and behind the external auditory meatus remote from the film, with the tube straight, using a small extension cone. Both sides should be taken for comparison.

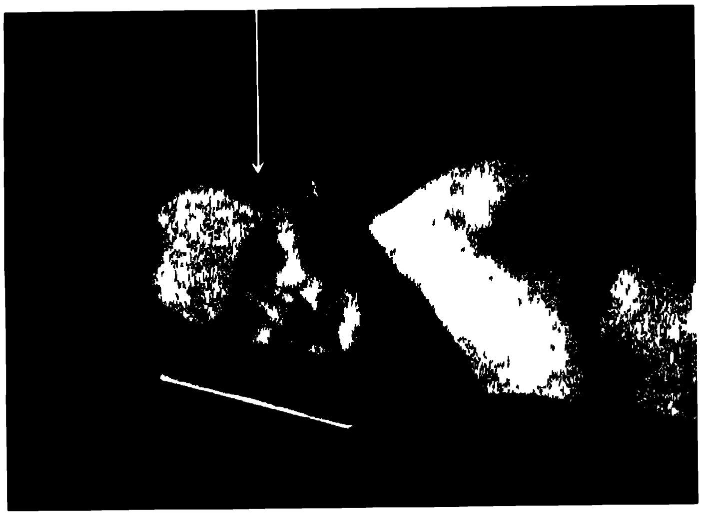
(707, 708, 709, 710)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	40	24	28″	Ilford	Tungstate	—

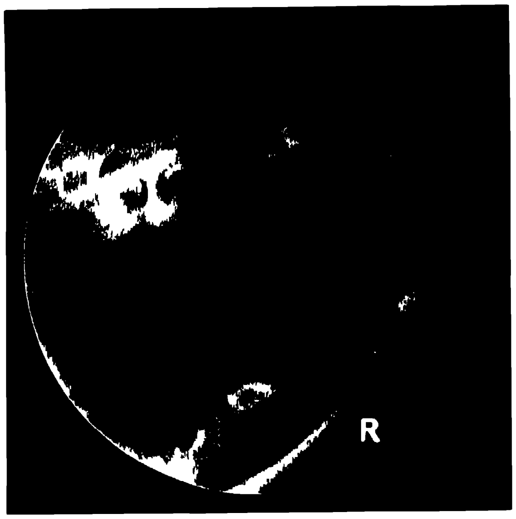
Small cone size of film, 6½ × 4¾ in or 8½ × 6½ in.

Satisfactory views are obtained, but it is not always possible to reproduce exactly the same position from side to side, and the more accurate methods of positioning shown on the following pages are recommended.

711



712



713

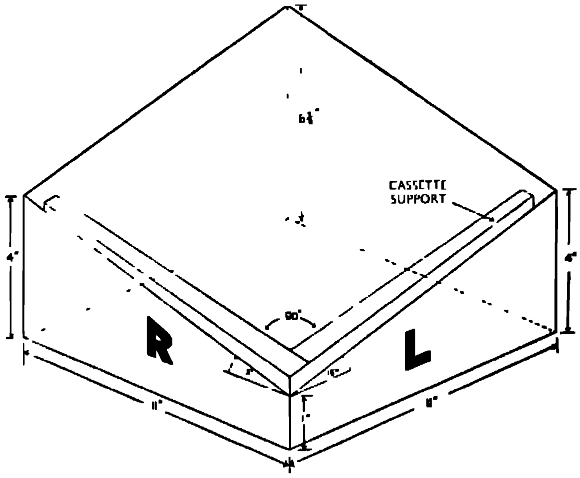
Temporal Bones: Mastoid

LATERAL OBLIQUE (2)—ANGLE BOARD

In this position the face is rotated 15 degrees forward and inclined 15 degrees downward, using either the angle table shown in (711), with the patient seated, or the angle block shown in (712, 714), with the patient either seated or lying full length on the couch.

The auricle of the ear is folded forward (707) and the head placed with the median plane parallel, and the inter-orbital line at right-angles, to the angle board.

The measurements of a suitable angle block are given in (714).



714

CENTRE 2 inches above and behind the external auditory meatus, with the tube straight, using a small extension cone.

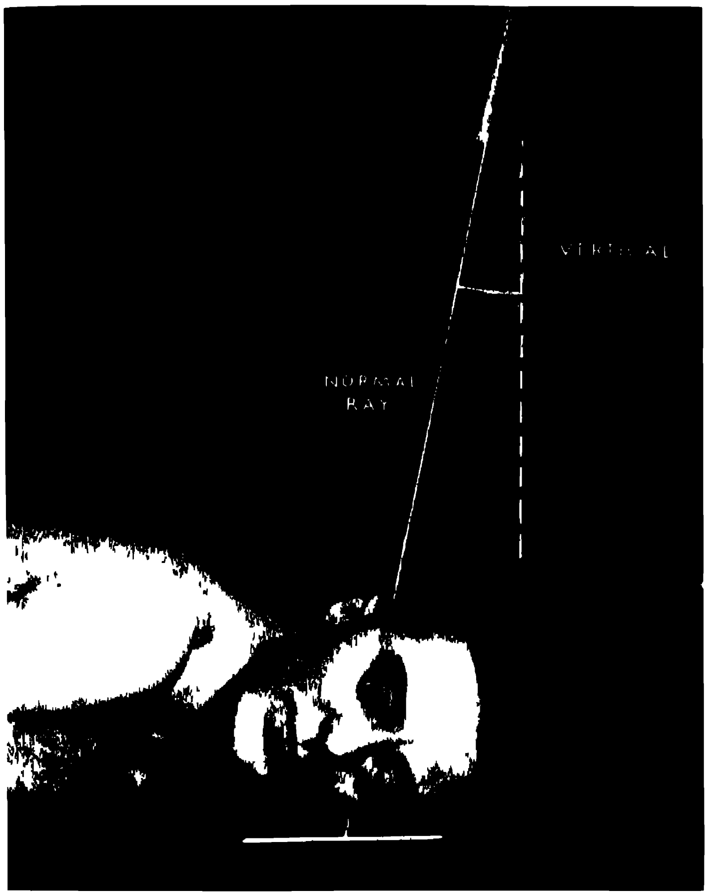
(711, 712, 713)

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	40	24	28"	Ilford	Tungstate	–

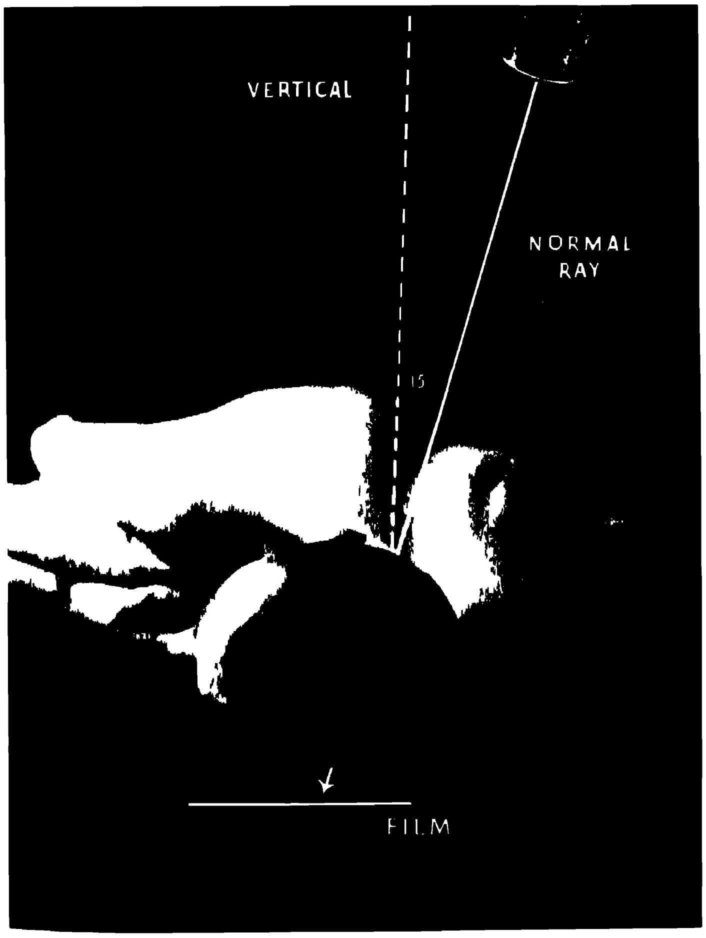
Small cone: size of film, 6½ × 4¾ in. or 8½ × 6½ in.

NOTE—This is similar to the previous position, but is more satisfactory in that it allows greater precision from side to side and from one patient to another.

Temporal Bones: Mastoid



715



716

LATERAL OBLIQUE (3) – TUBE ANGLED

For this view the head is maintained in the true lateral position, either erect or horizontal, and the tube angled to obtain separation from right to left.

The auricle of the ear proximal to the film is folded forward, as for the two previous views.

CENTRE 2 inches above and 2 inches behind the external auditory meatus remote from the film, with the tube angled 15 degrees toward the face and 15 degrees toward the feet, the axial ray passing through the mastoid proximal to the film.

(715, 716)

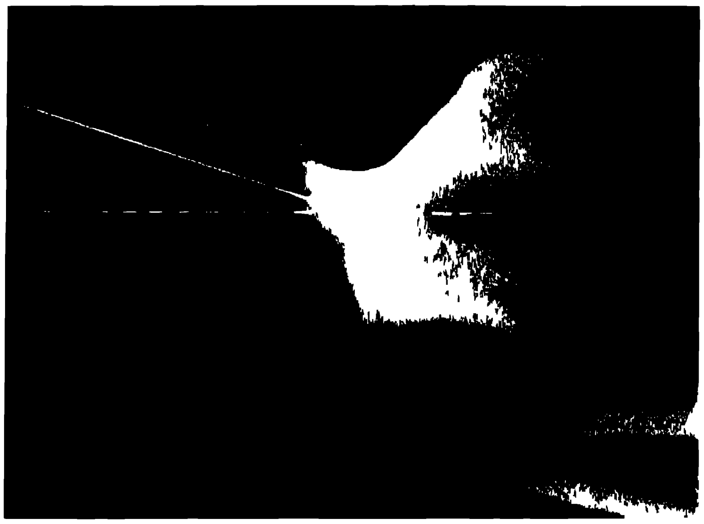
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	40	24	28″	Ilford	Tungstate	

Small cone size of film, 8½ · 6½ in.

This method, depending entirely on tube angulation, may be found to be more difficult to apply, as the *double* tube angulation toward the correct centring point is not easy to adjust unless a centre finder or long extension cone is used.

The resulting radiographs will be similar to those shown under (713) on the previous page.



717

718

Temporal Bones

Petrous Part

Before commencing this examination of the middle and internal ear reference should be made to the illustrations and anatomical description of this region on pages 246 and 247.

Radiographs are taken of each side separately, either from the posterior oblique or lateral oblique aspects. In films exposed from the occipito-frontal, fronto-occipital, mento-vertical and vertico-submental aspects both sides are shown following a single exposure.

The patient may be examined in either the horizontal or erect position. A fine-focus tube and small localising cone are essential; the Potter-Bucky diaphragm is used whenever possible and every effort made to obtain good contrast and definition, while, owing to the great density of this region, a fairly high kilovoltage is required.

IMPORTANT.—In exposing from the postero-anterior oblique and lateral oblique aspects it is frequently necessary to vary either the centring point or the position of the head to suit the patient. This can only be determined by trial exposures and the evidence of the resulting films.

OBLIQUE (1)—POSTERO-ANTERIOR

The patient is placed with the head in the occipito-frontal position: the head is first bent at an angle of 15 degrees from the axial line of the trunk, *away from* the side being examined (717), and then turned through 45 degrees *toward* the side being examined, to bring the superior border of petrous temporal parallel to the film (718). This position can be checked by applying the protractor from the end of the couch (719). In the erect position the head clamp is applied to the bi-temporal diameter of the head to obtain the correct angulation as shown by the head clamp protractor.

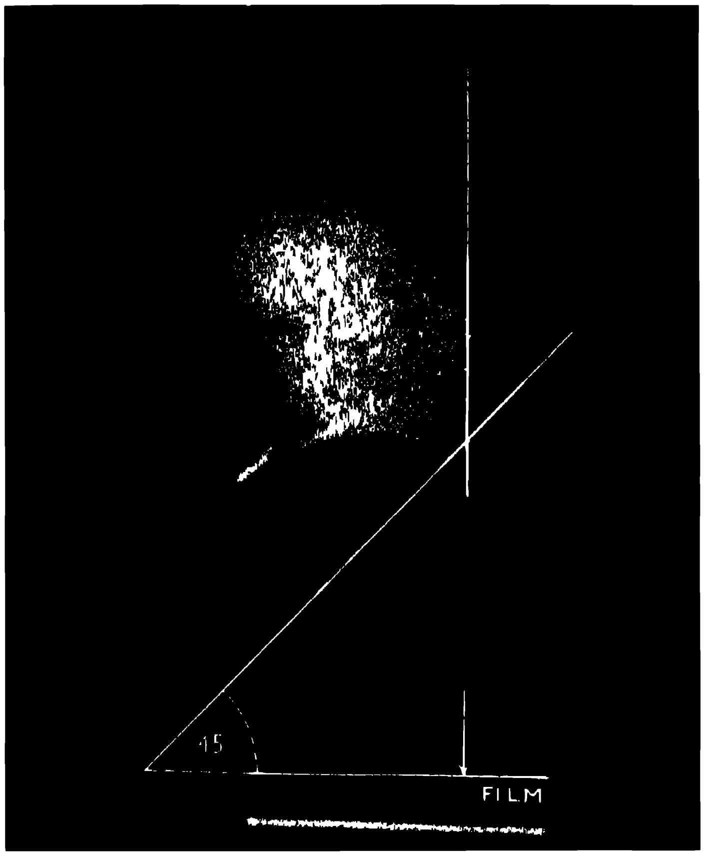
The base-line-film angle is finally adjusted to 85 degrees toward the feet (718).

CENTRE with the tube angled 12 degrees toward the head and over the occipital protuberance.

A variation of $1\frac{1}{2}$ inches to either side of this centring point may be found necessary to show the labyrinth, but this can only be determined for each subject on the evidence of the initial film.

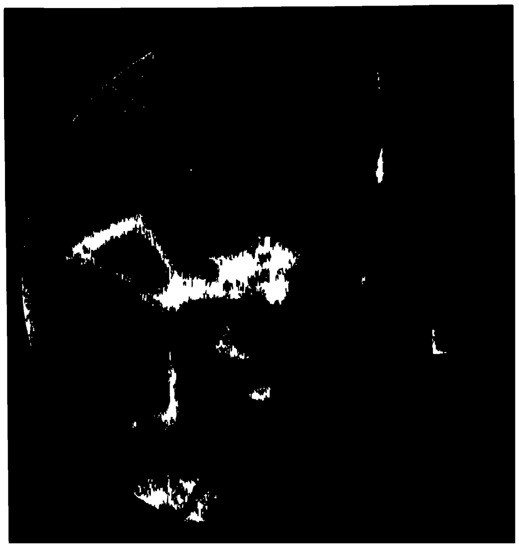
(717, 718, 719, 719a, 720, 721)

It should be noted that positioning is shown for the right side of the head in (717) and (718), and for the left side of the head in (719) and (719a).



719

720



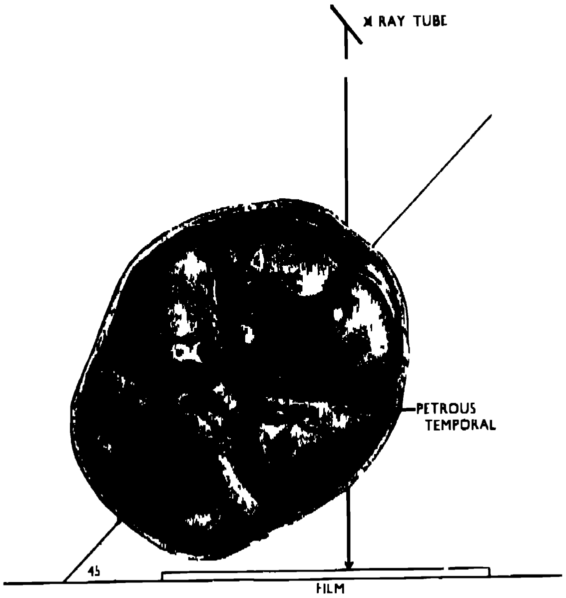
721

Temporal Bones: Petrous

OBLIQUE (1)—POSTERO-ANTERIOR
(continued)

EXPOSURE FACTORS							
	mA Secs						
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	46	28	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 8½ × 6½ in

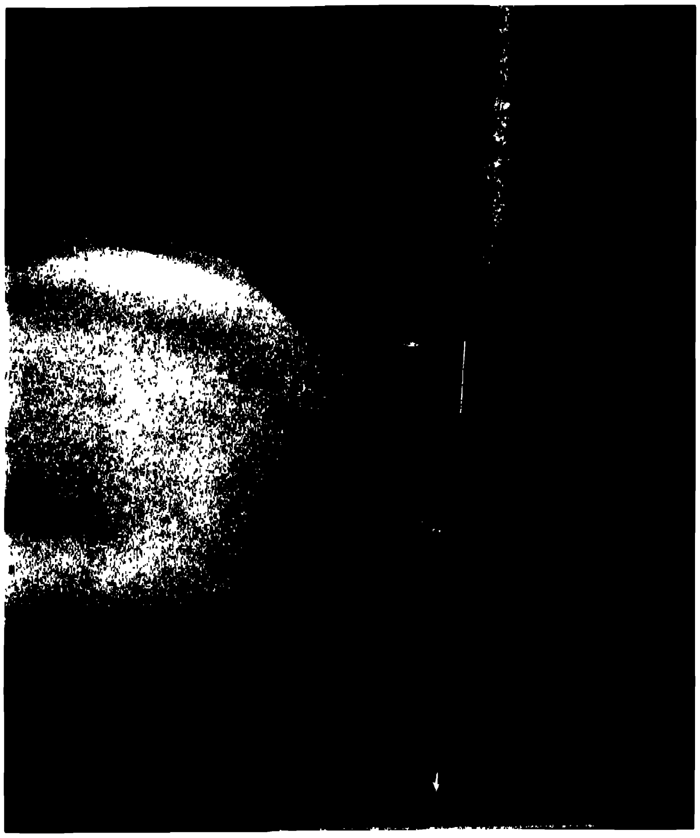


719a

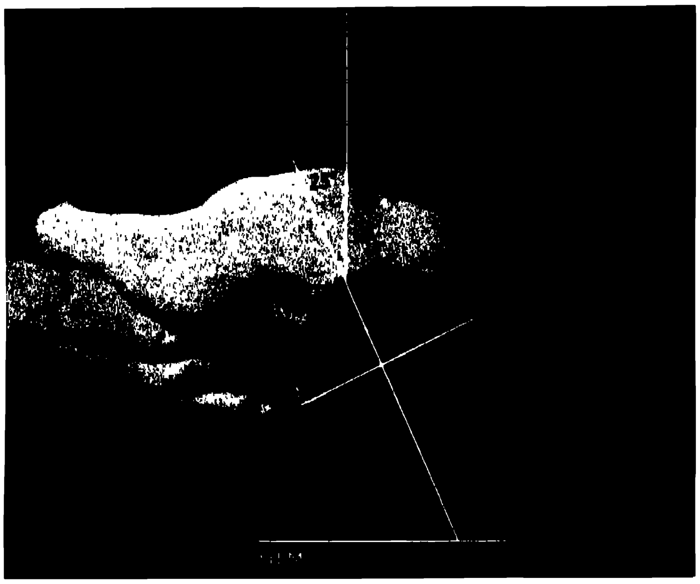
The illustration of the transverse section of the dried skull (719a) is positioned and lined to show the relationship of the petrous portion of the temporal bone to the film and tube, and to emphasise the necessity for exact head adjustment to bring the petrous temporal parallel to the film to enable satisfactory projection to be made.

Of the three positions described this is the most satisfactory for showing the labyrinth.

Temporal Bones: Petrous



722



723

OBLIQUE (2)—POSTERO-ANTERIOR

With the patient facing the film, the head is placed in the occipito-frontal position and then rotated through 25 degrees to 30 degrees toward the affected side. Both sides are taken for comparison.

CENTRE over the occipital protuberance, or $1\frac{1}{4}$ inches to either side of the occipital protuberance, as required, with the tube angled 5 degrees to 10 degrees toward the feet.

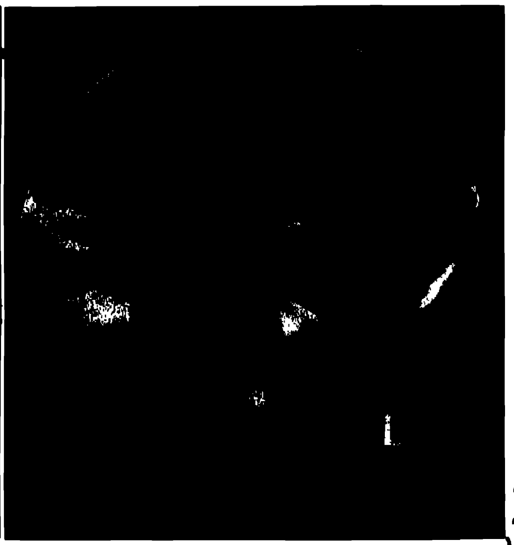
(722, 723, 724, 725)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	46	28	30″	Ilford	Tungstate	Potter-Bucky

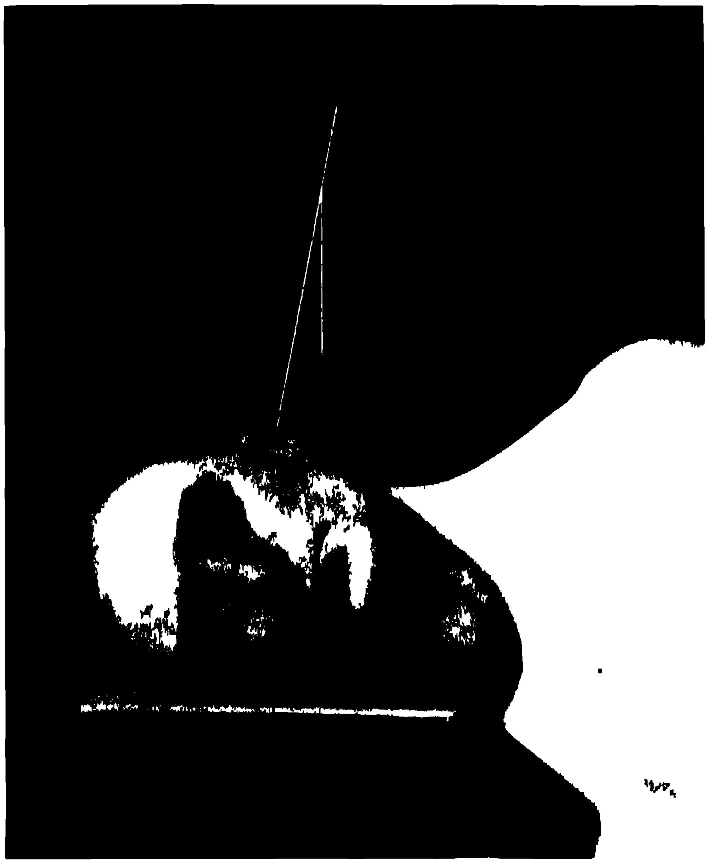
Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in. or $8\frac{1}{2} \times 6\frac{1}{2}$ in.

NOTE—Tilting the head forward into the nose-forehead position and rotating the head toward the affected side brings the superior border of the petrous temporal parallel to the film, and angling the tube toward the feet assists in obtaining a useful projection to show the labyrinth clear of other basal structures. In this position the occipital protuberance is immediately over the centre of the petrous portion of the temporal bone. The tendency is to centre too near to the mastoid process.



724
725

Temporal Bones: Petrous



726

OBLIQUE (3)—HEAD LATERAL

The patient is placed with the head in the true lateral position.

CENTRE mid-way between the occipital protuberance and the external auditory meatus, with the tube angled 35 degrees toward the face and 10 degrees toward the head. The central ray passes through the medial aspect of the petrous bone adjacent to the film

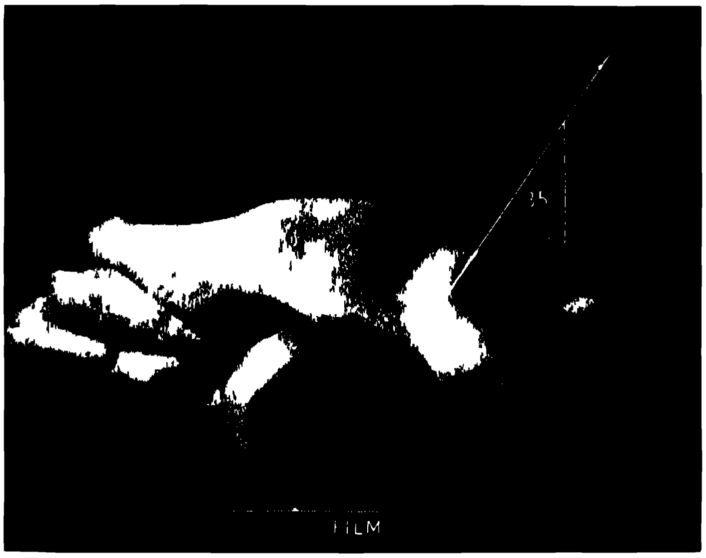
As an alternative the head may be rotated forward and the tube angle adjusted accordingly The Potter-Bucky diaphragm is not used for this view

(726, 727, 728, 729)

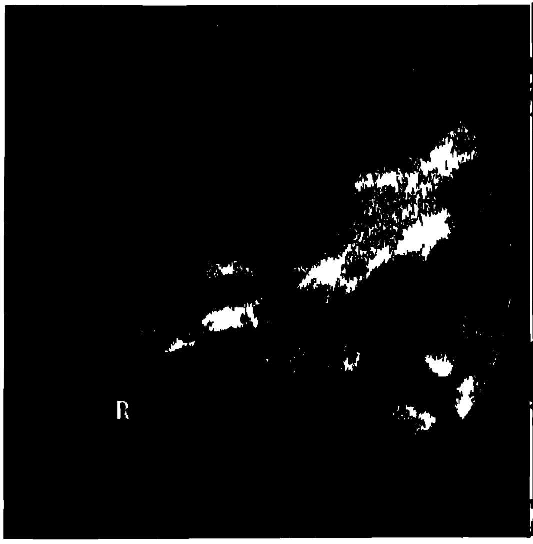
EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	16	10	30	Ilford	Tungstate	–

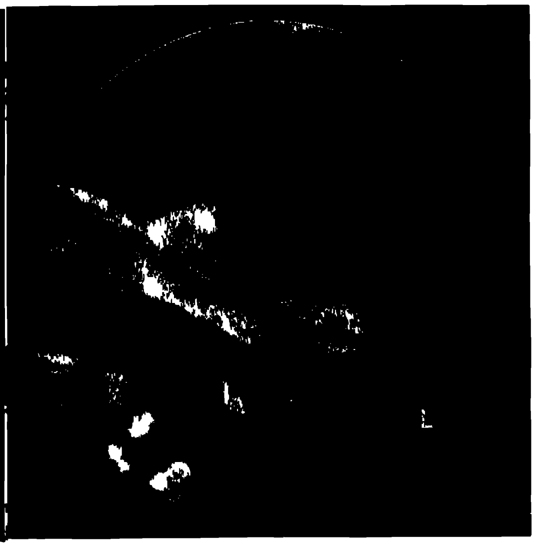
Cone to size of film, 8½ 6½ in

This is the simplest of the three positions described and is the most comfortable for the patient to maintain.



727





728
729

730

731

732

733

Temporal Bones: Petrous

25 DEGREES OCCIPITO-FRONTAL

In this position both temporal bones may be shown at a single exposure. The head is adjusted to the occipito-frontal position, that is, with the base line at right angles to the film.

CENTRE to the nape of the neck, through the foramen magnum and toward the frontal bone, with the tube angled 25 degrees toward the head.

(730, 731)

25 DEGREES FRONTO-OCCIPITAL

This position, the reverse of **(730)**, may be used as an alternative to show the two sides at a single exposure, but in view of the oblique position of the petrous temporals within the skull, positioning distortion may be more marked.

With the patient facing the tube, the head is placed in position with the chin well in toward the chest, to bring the base line at right angles to the film.

CENTRE through the frontal bone toward the foramen magnum, with the tube angled 25 degrees toward the feet.

(732, 733)

EXPOSURE FACTORS

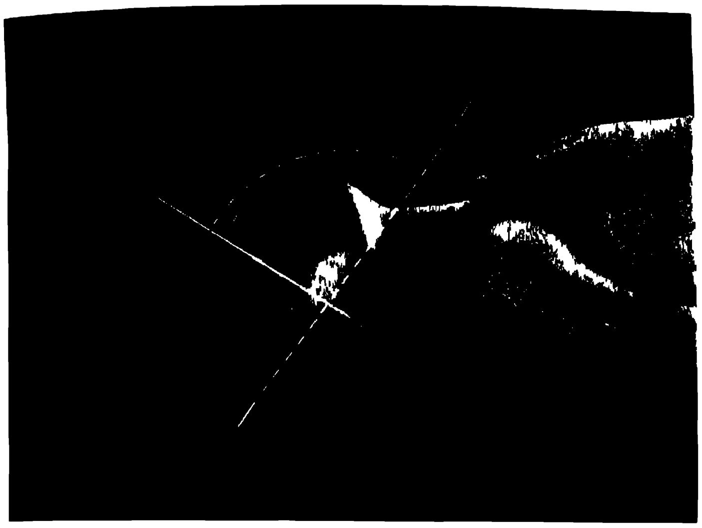
kVp.	mA. Secs Ilford X-ray	mA. Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	82	50	44″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in.

The same exposure factors apply for both views.

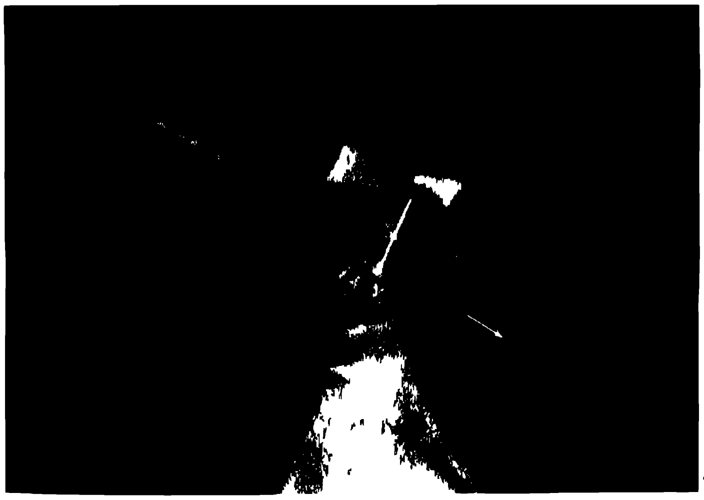
AUDITORY NERVE TUMOUR

Investigation for the purpose of demonstrating the presence of an auditory (eighth) nerve tumour should include films showing the petrous portion of the temporal bone, and particularly the internal auditory meatus, both sides being exposed for comparison, either separately, as in **(720, 721)**, **(724, 725)**, or simultaneously as in **(731, 733)**.

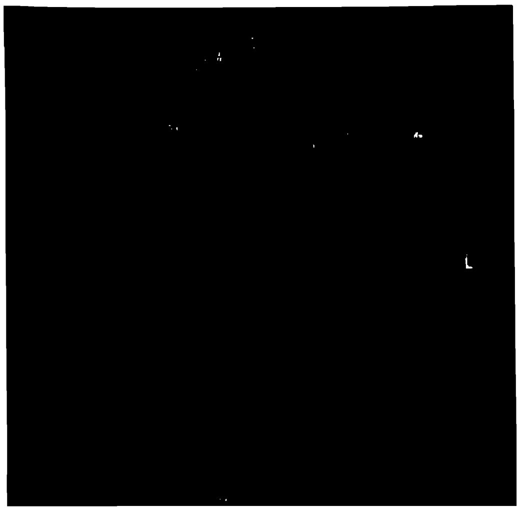


734

735



736



737

Temporal Bones: Petrous

The petrous portions of the temporal bones are clearly shown in films exposed at right angles to the base of the skull, as seen in the accompanying radiographs taken with the patient in the mento-vertical and vertico-submental positions. A narrow rectangular diaphragm should be used for these views: in the illustrations larger areas are included for the purpose of showing the general relationship of the temporal bones and other bone structures.

MENTO-VERTICAL

The patient is placed in position facing the tube, with the head extended to bring the vertex of the skull into contact with the film support, the ideal position being attained when the base line is parallel to the film.

CENTRE between the angles of the jaw, with the tube angled toward the head at 95 degrees to the base line and parallel to the general line of the face.

(734, 735)

VERTICO-SUBMENTAL

With the patient facing the film, the neck is extended to bring the inferior aspect of the mandible toward the film.

CENTRE through the vertex toward the mid-line between the angles of the jaw and at an angle of 95 degrees toward the feet.

(736, 737)

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	200	120	48"	Ilford	Tungstate	Potter-Bucky

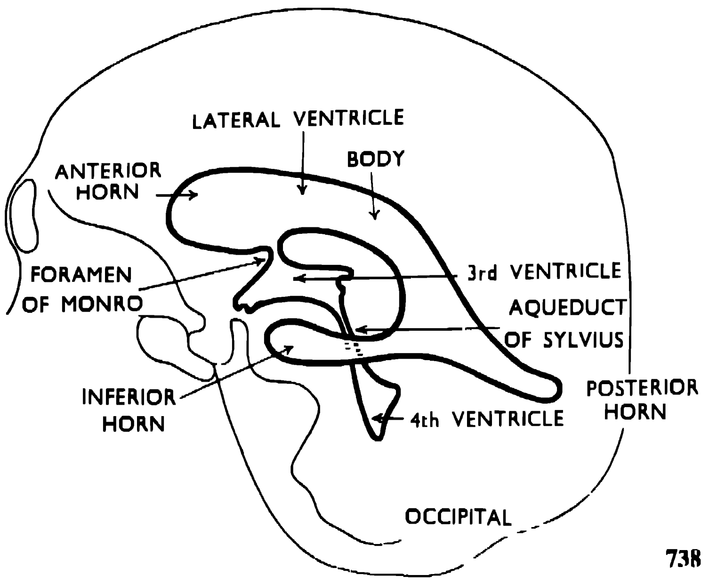
Cone to size of film, 10 × 8 in.

The same exposure factors apply for both views, which may be taken in either the erect or horizontal position. Considerable penetration is required to show detail in the petrous temporals.

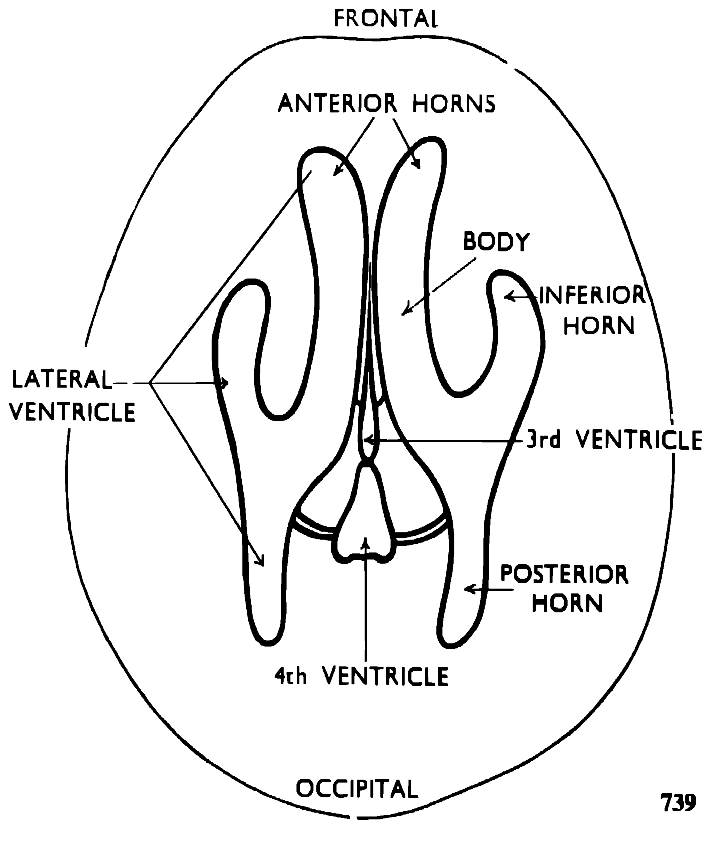
It should be noted that the foramina—ovale, rotundum, and spinosum are well demonstrated in (737).

SECTION 15

Ventriculography and Encephalography



738



739

VENTRICULOGRAPHY AND ENCEPHALOGRAPHY

The ventricular system of the brain consists of four ventricles—two lateral ventricles and two others named, respectively, the third and the fourth ventricle. Normally they contain cerebro-spinal fluid, which is of the same density as the brain substance. For the purpose of radiographic examination, some of this cerebro-spinal fluid is replaced by air in order to obtain the necessary contrast for demonstration. Since the position of the air varies as the patient is moved, a complete examination of the ventricles may be carried out by changing the position of the head so that each part of the ventricular system is, in turn, filled with air.

In the accompanying illustrations **(738, 739)** the ventricles are shown diagrammatically in order to indicate to the student their relationship to the bony cranium as seen from the lateral and superior aspects.

The lateral ventricles are situated one in each hemisphere of the brain: they are separated in the mid-line, and communicate by way of the foramina of Monro with the third ventricle. Each lateral ventricle consists of a body and anterior, posterior, and inferior horns.

The third ventricle is situated in the mid-line, between and below the level of the anterior horns, and above the level of the inferior horns, of the lateral ventricles. It communicates with the lateral ventricles, which are above and in front of it, by the foramina of Monro, and with the fourth ventricle, situated below and behind it, by the aqueduct of Sylvius.

The fourth ventricle is also situated in the mid-line, but is considerably lower than the inferior horns of the lateral ventricles. It communicates above, by the aqueduct of Sylvius, with the third ventricle, and is continuous below with the central canal of the medula oblongata.

The introduction of air into the ventricles for the purpose of their demonstration may be made directly, following a trephining operation, when it is termed *ventriculography*, or by means of a lumbar puncture, when it is known as *encephalography*.

In *ventriculography* the smallest possible dressing only should be strapped to the head wound after the introduction of the air to facilitate correct positioning of the head for examination, this positioning being rendered very difficult, if not almost impossible, by a very heavy dressing.

Ventriculography and Encephalography

In *encephalography* the patient is maintained in the sitting posture during the lumbar injection in order that the air introduced may rise to the ventricles and assume a position above the level of the cerebro-spinal fluid. This technique is sometimes employed for initial exploratory examination.

The patient usually suffers more discomfort following the lumbar puncture method than by the previous direct injection into the ventricles. Radiographic procedure is the same in both ventriculography and encephalography.

APPARATUS

The Lysholm skull table is particularly adapted for this examination as the position of tube and film can be readily varied without undue movement of the patient. With a little care and forethought, however, equally satisfactory results may be obtained with the ordinary couch, vertical stand and mobile tube support. Where the Lysholm table is shown in the illustrations reference is also made to similar positioning on the standard couch as discussed in Section 9.

It is beyond the scope of this book to give full details of the Lysholm skull table, but to prevent misunderstanding of the photographs the following features should be noted.

The tube focus, at all angles of the tube, is always central to the grid and film. In the illustrations the centre-finder is shown pointing in the direction of the central or axial ray; it is hinged, and can be moved to one side during the exposure. The tube moves through 180 degrees in relation to the grid surface, allowing lateral projections to be made without moving the patient, but without the grid. Tube and grid also move through 90 degrees to allow of both erect and horizontal positioning.

The grid moves on its axis, allowing the grid slats to be adjusted to the direction of the X-ray beam when the tube is angled in relation to the normal position.

The positioning of the head in relation to the film is facilitated by the use of reflecting mirrors placed beneath the transparent table top, which operate when the grid is removed, and, by the presence of hinges, allowed to hang vertically beside the table. The unit, consisting of small grid and freely movable tube, is separate from the full-length simple type of couch, and can, therefore, be moved vertically in relation to the couch, thus allowing for the dropped head positions necessary in ventriculography.

In place of localising cones, lead discs are used, a slot being provided for their insertion within six inches of the tube. These discs have various sized circular and rectangular apertures to suit all skull projections.

POSITIONING

In the order of positioning shown it should be noted that for each position of the *head* films are taken from the several aspects in order to avoid undue movement of the patient:—

PATIENT SUPINE

Fronto-occipital—tube straight.
Fronto-occipital—tube angled 30 degrees.
Lateral—right and left.

PATIENT PRONE

Occipito-frontal—tube straight.
Occipito-frontal—tube angled 30 degrees.
Lateral—right and left.

PATIENT LATERAL

Lateral right.
Lateral left.

PATIENT SUPINE

Head lowered—lateral.

PATIENT VERTICAL

Fronto-occipital.
Lateral.

Stereoscopic exposures are frequently made from one or more aspects of the head, the tube-shift being parallel to the median line of the head for both antero-posterior and postero-anterior views.

Again, there are many variations in the technique adopted by the individual radiologist, and only a small number of the positions quoted above may be required, or on the other hand, other positions may be preferred.

In changing the position of the head a gentle rocking movement assists the filling of the ventricles, but jerky movements should be avoided or the patient's sensation of nausea will be intensified, and in some positions of the head the air may pass out of the ventricular system. A brief interval between each movement of the patient should be allowed to enable the air to move to the new position within the ventricles.

The quantity of air injected into the ventricular system is decided in the operating theatre, and may vary from 10 cubic centimetres to 200 cubic centimetres; less than 10 cubic centimetres is unsatisfactory, 30 to 40 cubic centimetres being the average quantity introduced.

In the text a photograph, radiograph and diagram are shown for each view of the ventricles, and on pages 278 and 279 a complete set of radiographs is shown for comparison, the lateral views being placed in the position in which they were exposed.

740

Ventriculography and Encephalography

(1) SUPINE--FRONTO-OCCIPITAL

The patient is supine on the couch, and the head is carefully adjusted with the base line and median plane at right angles to the film. The head is also centred to the grid and to the correct centring point as shown by the tube indicator. The standard Potter-Bucky couch is shown in use for this position on page 179.

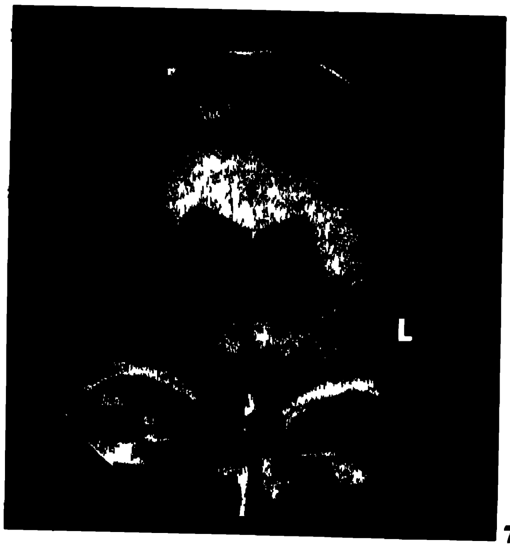
CENTRE through the forehead, above the glabella.

(740, 741, 742)

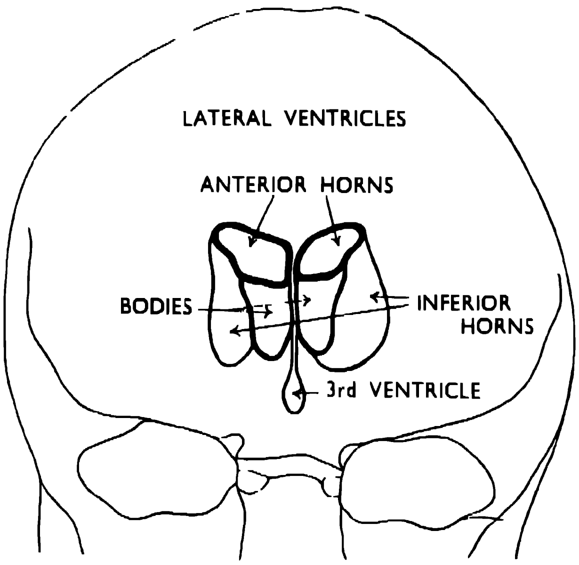
EXPOSURE FACTORS

	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
63	77	47	28	Ilford	Tungstate	Lysholm Moving
65	128	78	36"	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in or 10 × 8 in

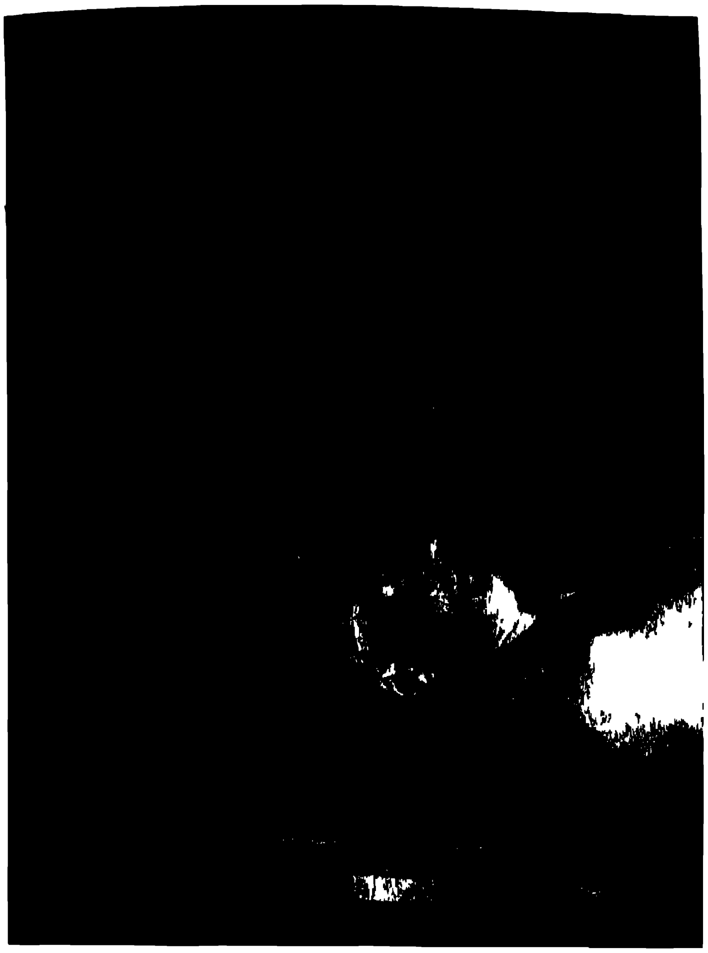


741



742

NOTE—In this position of the head the air rises to fill the anterior horns of the lateral ventricles, and sometimes a part of the third ventricle, as may be seen in radiograph **(741)** and in the tracing diagram **(742)**.



743

Ventriculography and Encephalography

(2) SUPINE—30 DEGREES FRONTO-OCCIPITAL

With the patient in the same position as for the previous view, the tube is moved from the vertical and angled 30 degrees toward the feet. As in this particular table the tube is always automatically centred to the small-area grid, it is necessary to move the patient toward the tube in order to obtain the correct centring point.

In using the standard Potter-Bucky couch this movement of the patient is avoided, as both tube and grid can be adjusted to the patient, page 180.

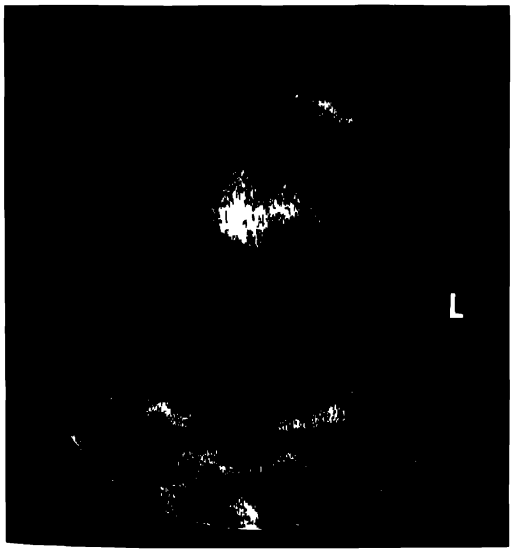
CENTRE through the forehead, toward the foramen magnum, with the tube angled 30 degrees toward the feet.

(743, 744, 745)

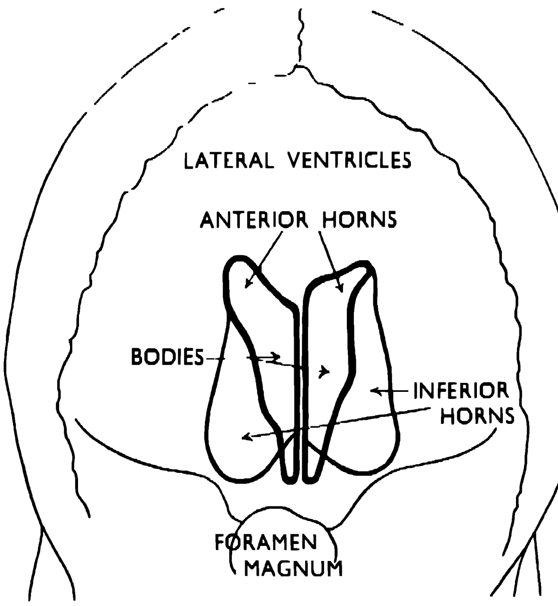
EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
63	80	48	28″	Ilford	Tungstate	Lysholm Moving
65	132	80	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

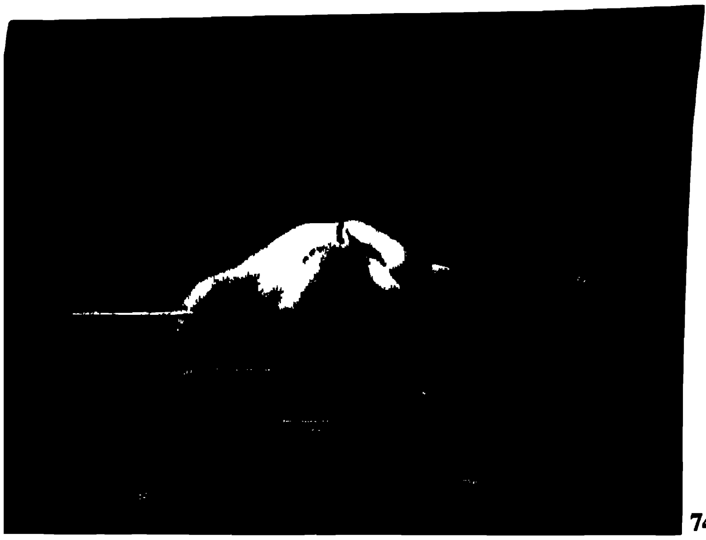


744



745

NOTE—The tube adjustment allows the air-filled anterior horns of the lateral ventricles to be seen from a different aspect, as shown in the radiograph (**744**) and also in the tracing diagram (**745**).



746

(3) SUPINE—LATERAL

The head is moved gently backward and forward to encourage the passage of the air into the third ventricle, and then placed in the same position as for the two previous views. The tube is moved round the head, through 90 degrees, to the horizontal position, and the film is placed vertically against the lateral aspect of the head. In this instance the grid may be omitted.

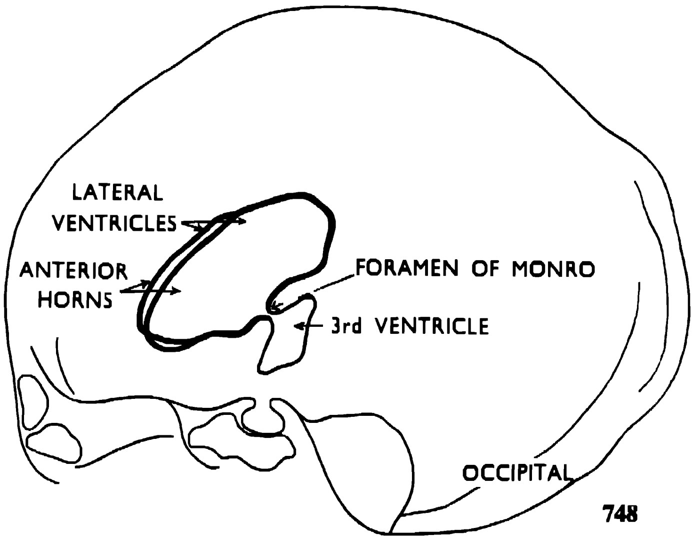
Reference to page 175 will show the same view taken on the standard couch, with the tube of the ward mobile unit in the horizontal position.

CENTRE approximately 2 inches above the external auditory meatus. Films are exposed from right and left sides in turn. **(746, 747, 748)**

EXPOSURE FACTORS							
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	33	20	28"	Ilford	Tungstate	Lysholm Station-ary

Cone to size of film, 10 × 8 in or 12 × 10 in

747

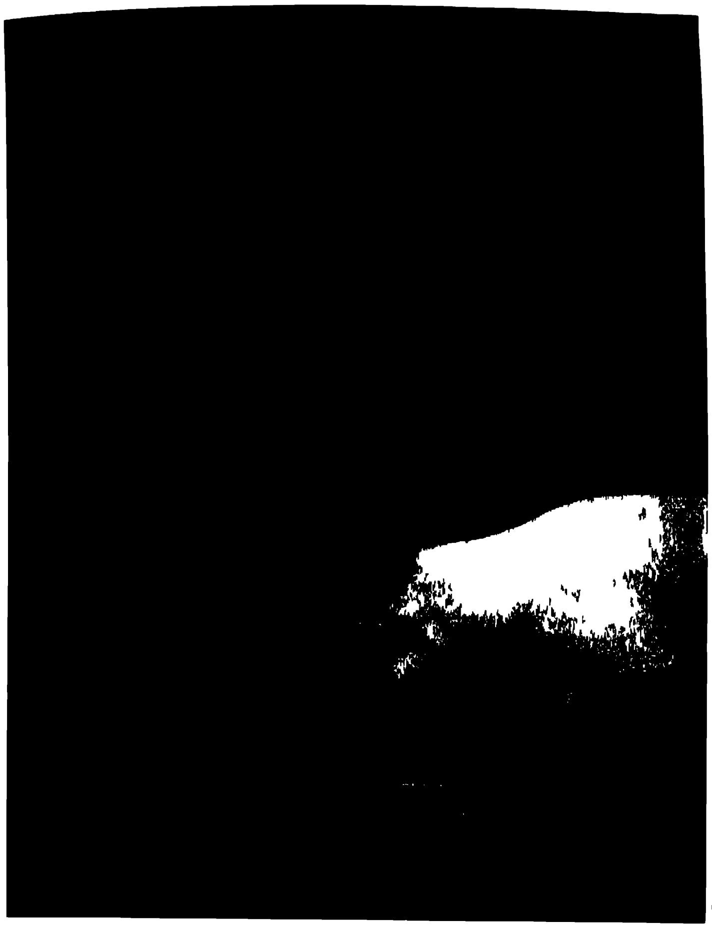


748

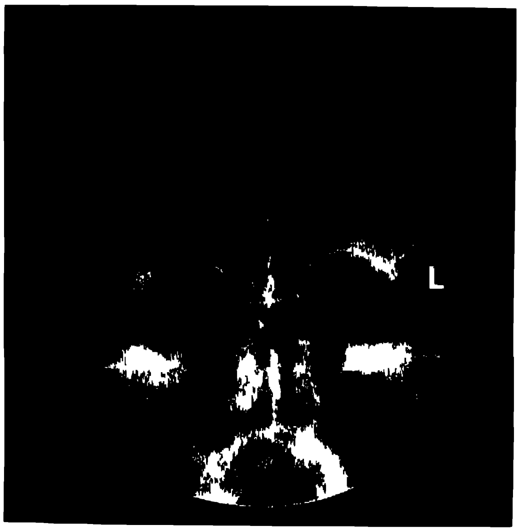
NOTE—In this view the anterior horns of the lateral ventricles and the third ventricle are shown. The stationary Lysholm grid was used for radiograph **(747)**.

By turning the radiograph clockwise through 90 degrees it will be seen in the position in which it was exposed, as is shown also on page 278.

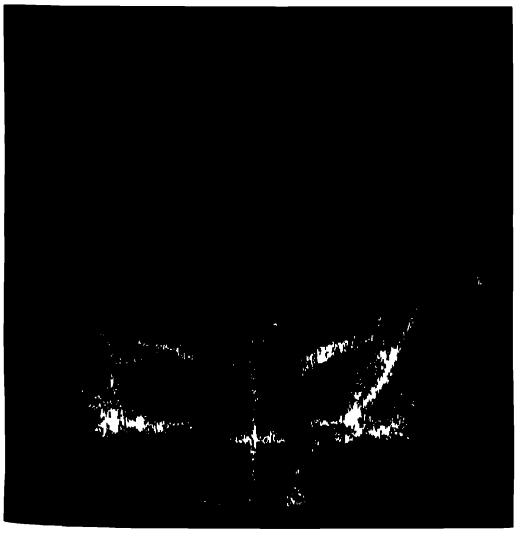
This view completes the *supine* series, the adjustment in tube centring having allowed the air-filled portion of the ventricular system to be seen from an aspect at right angles to the two previous views. This is also the "key" film to the antero-posterior views should there be any doubt as to the actual portion of the ventricular system shown.



749



750



Ventriculography and Encephalography

(4) PRONE—OCCIPITO-FRONTAL

The patient is gently turned from the supine to the prone position and the head adjusted with the base line and median plane at right angles to the film, with the centring point above the occiput and in line with the tube indicator, which is automatically centred to the grid and film.

The same position on the standard couch is shown on page 177.

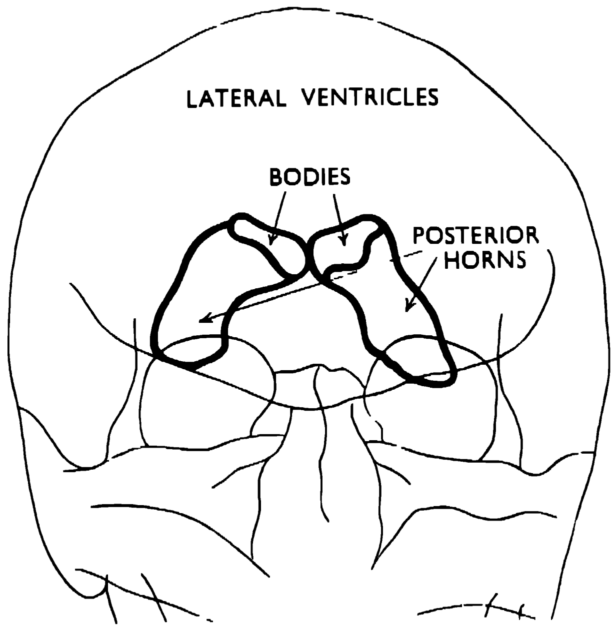
CENTRE above the occipital protuberance and toward the frontal bone, this being the reverse of position (1).

(749, 750, 751)

EXPOSURE FACTORS

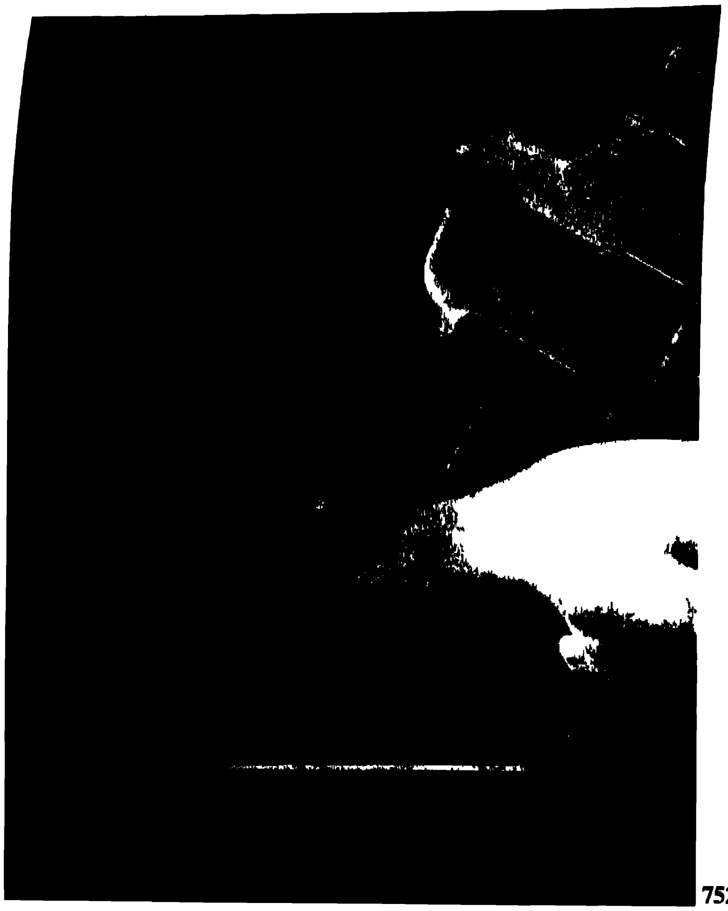
kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
63	77	47	28″	Ilford	Tungstate	Lysholm Moving
65	128	78	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.



751

NOTE—With the head in this position the air rises from the anterior horns to fill the posterior horns of the lateral ventricles, as will be seen in the radiographs **(750)** and tracing diagram **(751)**. A second radiograph is included as although the posterior horns are well shown in the first, the positioning of the *head* is more satisfactory in the second: filling in this instance, however, is incomplete.



752

(5) PRONE—30 DEGREES OCCIPITO-FRONTAL

With the head in the same position, the tube is angled 30 degrees toward the vertex, centring to grid and film being automatic. The patient is moved toward the tube and positioned to the correct centring point. When the standard couch is used, on the other hand, the tube and grid are moved in relation to the patient, as shown on page 186.

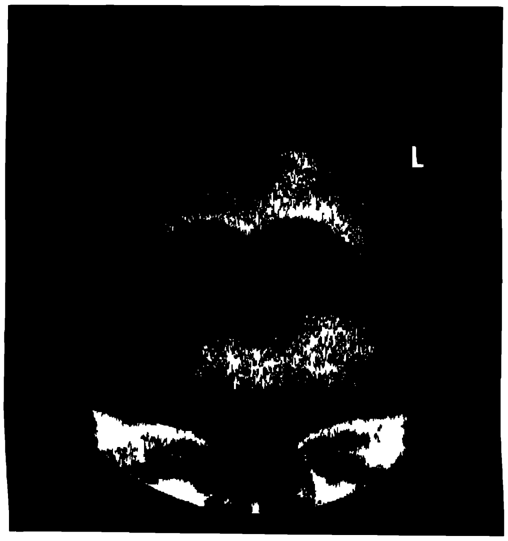
CENTRE through the nape of the neck and toward the forehead, with the tube angled 30 degrees toward the head.

(752, 753, 754)

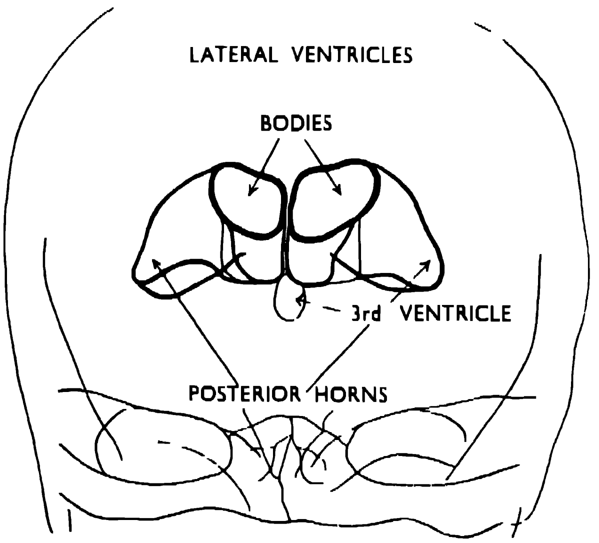
EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
63	80	48	28	Ilford	Tungstate	Lysholm Moving
65	132	80	36′	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in or 12 × 10 in.



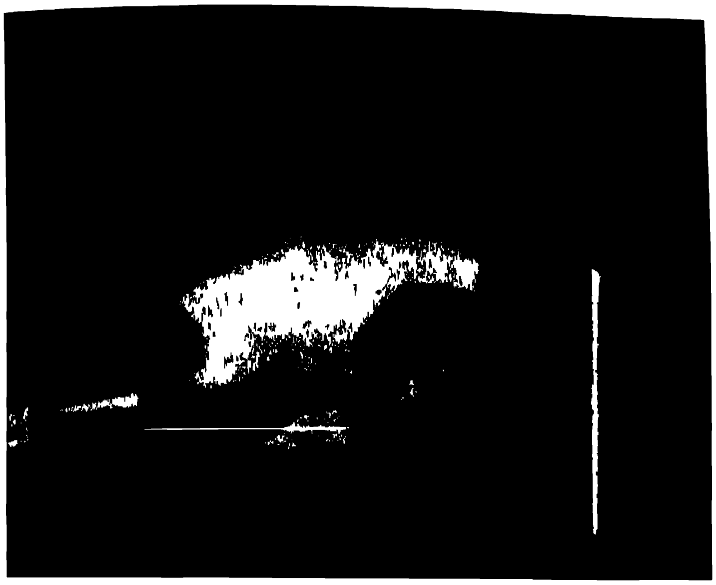
753

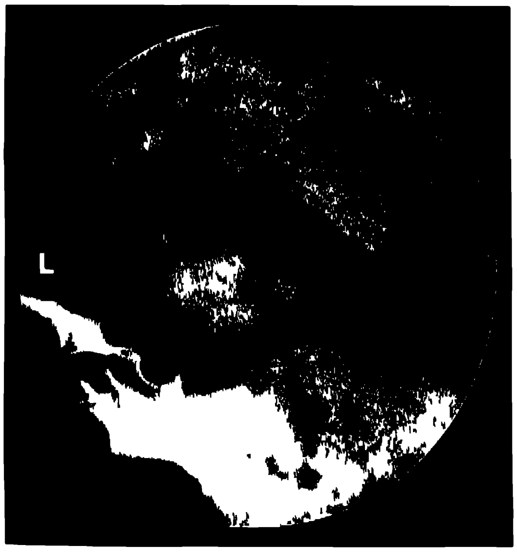


754

NOTE—This tube adjustment allows the air-filled posterior horns of the lateral ventricles to be seen from a different aspect, as shown in the radiograph (753) and tracing diagram (754).

Ventriculography and Encephalography


755



756

(6) PRONE—LATERAL

With the patient in the same position, the tube is moved round the head, through 90 degrees, to the horizontal position, and the film placed vertically to right or left lateral aspect of the head as required.

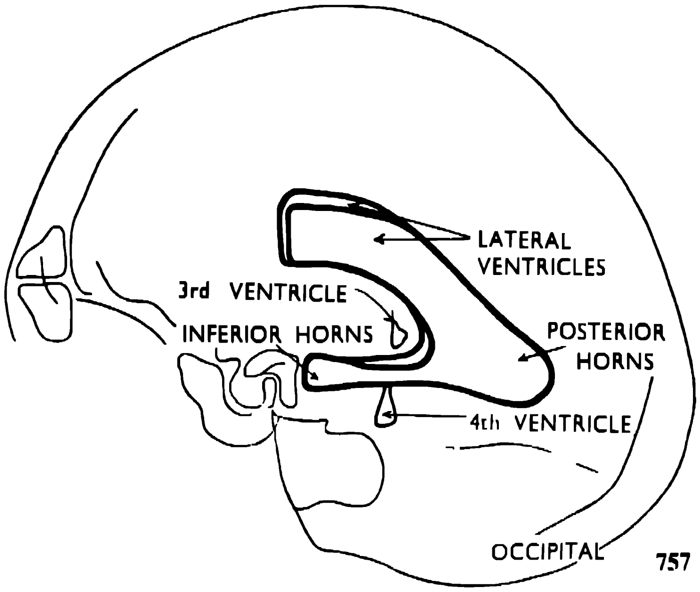
CENTRE from the horizontal position, approximately 2 inches above the external auditory meatus.

(755, 756, 757)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	33	20	28′	Ilford	Tungstate	Lysholm Stationary

Cone to size of film, 10 × 8 in. or 12 × 10 in



757

NOTE—In this view the posterior horns of the lateral ventricles and also a part of the third and fourth ventricles may be shown. The stationary Lysholm grid was used in taking radiograph (756). By turning the book anti-clockwise through 90 degrees the radiograph and tracing diagram (757) will be seen in the position in which the radiograph was exposed, as is shown also on page 278.

This view completes the *prone* series of films and allows the filling of the ventricles shown in the postero-anterior views to be appreciated. Reference for comparison with the *supine* position should be made to page 270.

758

(7) LATERAL

From the occipito-frontal position the head is gently moved through 90 degrees to right and left sides in turn, to occupy the true lateral position for the two exposures, the raised arm being supported on sandbags. A short lapse of time should be allowed between positioning and exposure to enable the air to rise to the new position

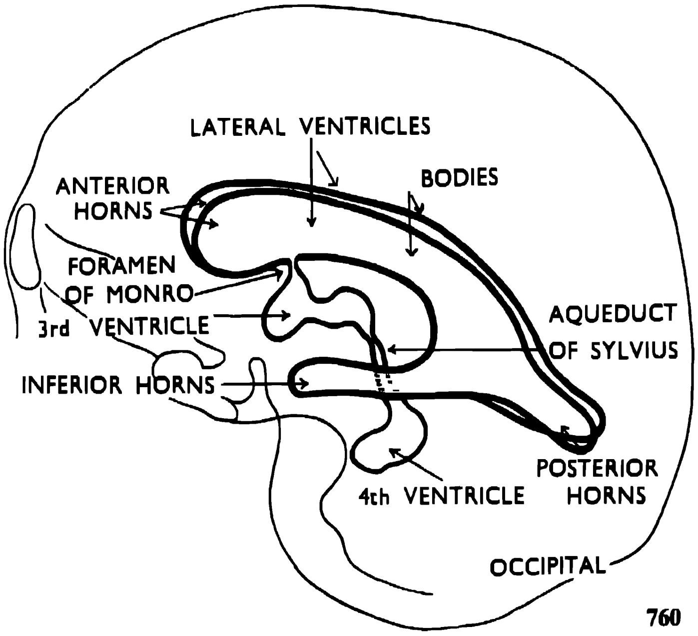
CENTRE 2 inches above the external auditory meatus

(758, 759, 760)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
58	42	25	28	Ilford	Tungstate	Lysholm Moving
60	70	43	36	Ilford	Tungstate	Potter-Bucky
60	33	20	28	Ilford	Tungstate	Lysholm Stationary
50	26	16	28	Ilford	Tungstate	—

Cone to size of film, 10 × 8 in or 12 × 10 in

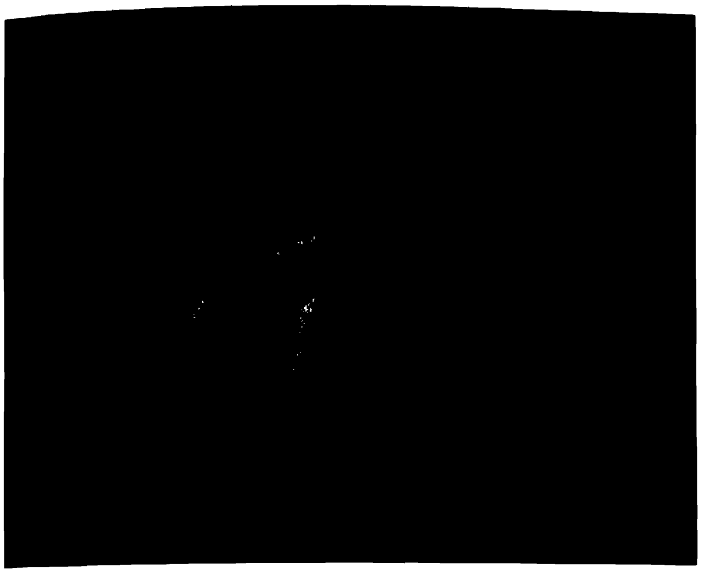
759



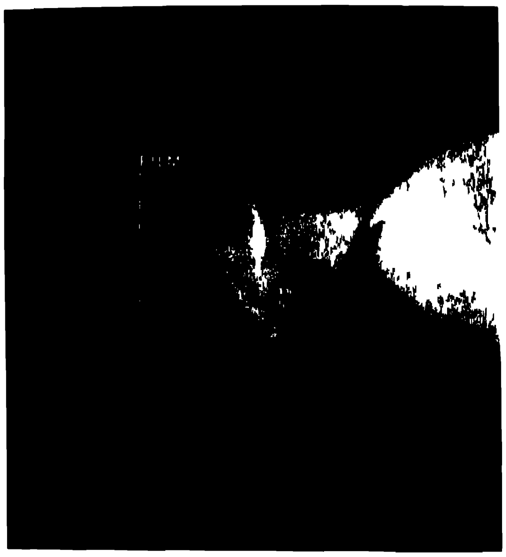
760

NOTE—With the head in the lateral position the air rises to fill the lateral ventricle remote from the film, and also the third and fourth ventricles and the communicating foramen of Monro and the aqueduct of Sylvius, as shown in the radiograph (759) and tracing diagram (760).

In order to show both lateral ventricles it is necessary to expose two films, one each with the head in the right and left lateral position



761



762

763

(8) SUPINE—LATERAL HEAD LOWERED

With the patient supine, the neck is allowed to extend until the vertex of the skull is in contact with the grid table, which is lowered in relation to the couch to enable the head to rest below the level of the shoulders.

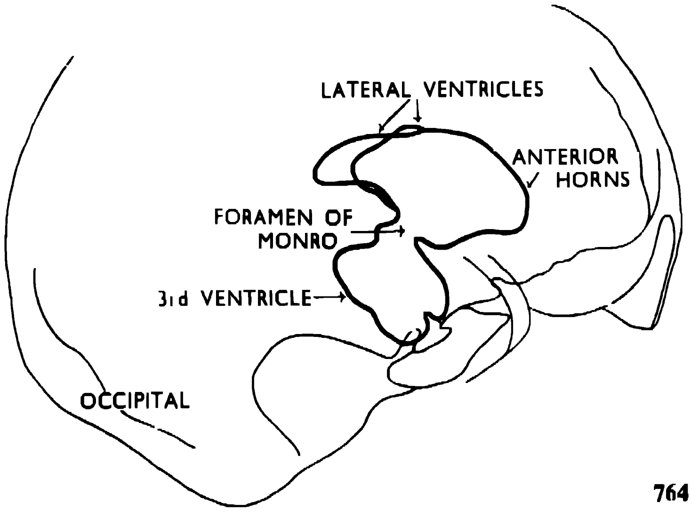
Gentle movements are essential and the extension of the neck should not be excessive, as with the head in this position the air is inclined to pass out of the ventricular system through the fourth ventricle. This position, therefore, usually terminates the examination.

The film is placed against the lateral aspect of the head and the tube moved through 90 degrees to the horizontal position.

When using the standard Potter-Bucky couch, a small table some 6 inches lower in height is placed against the end of the couch to enable the head to be lowered to the correct position, the film being supported in the vertical position, and the ward mobile unit used to project the X-ray beam from the horizontal position toward the head.

CENTRE 2 inches above the external auditory meatus with the tube in the horizontal position

(761, 762, 763, 764)



764

NOTE—As the head is moved into position the air rises to fill the third ventricle. This view shows, therefore, the anterior horns of the lateral ventricles, the foramina of Monro, and the third ventricle. Radiograph (763) was exposed without the grid.

By turning the book through 180 degrees the radiograph may be seen in the position in which it was exposed. Reference should be made also to page 279.

765

(9) ERECT—FRONTO-OCCIPITAL

The patient is seated facing the tube, the chin being lowered to bring the base line at right angles to the film.

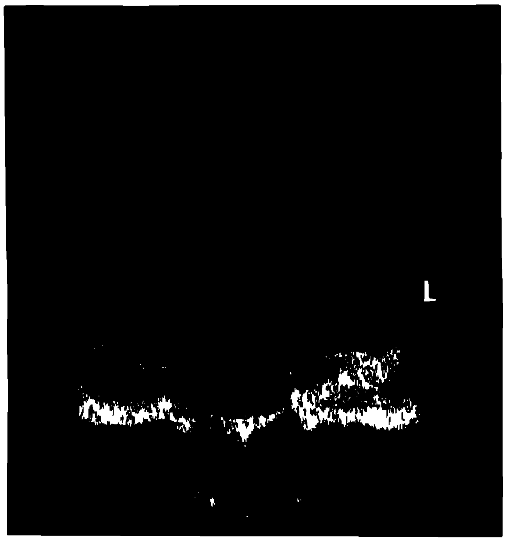
CENTRE to the forehead, with the tube horizontal.

(765, 766, 767)

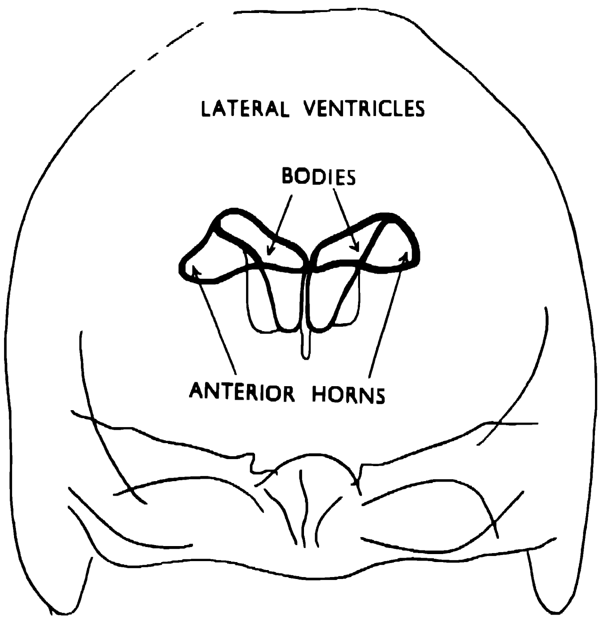
EXPOSURE FACTORS

kVp.	mA. Secs Ilford X-ray	mA. Secs Developers 'Blue Label'	Distance	Film	Screens Ilford	Grid
63	77	47	28'	Ilford	Tungstate	Lysholm Moving
65	128	78	36'	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 in. or 12 × 10 in.

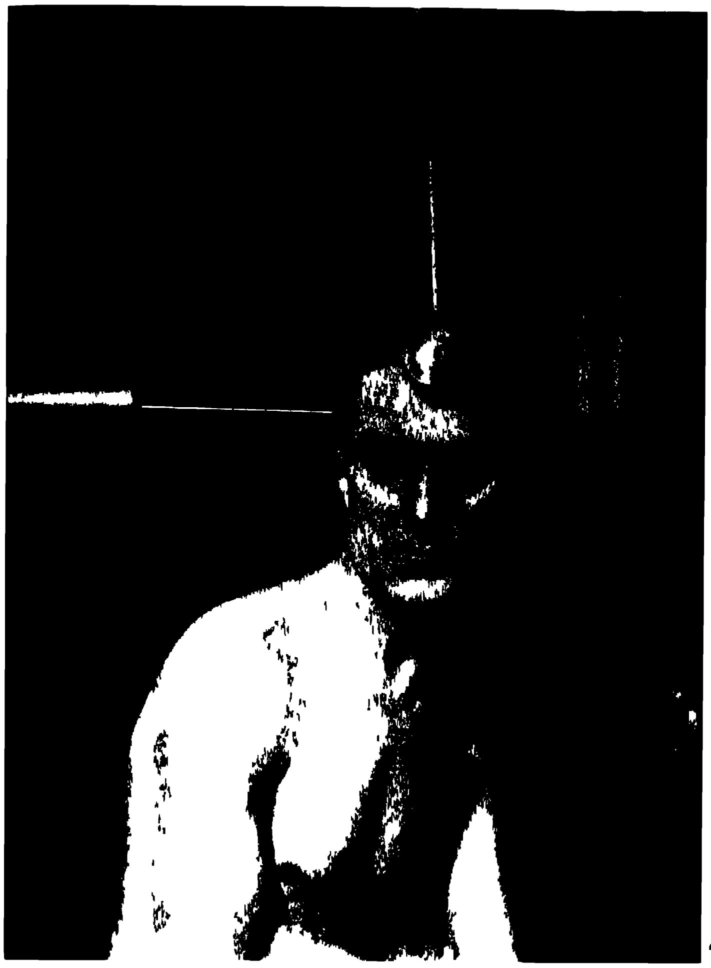


766



767

NOTE—The erect position of the head allows the air to rise to fill the uppermost portions of the lateral ventricles, showing chiefly the bodies and anterior horns, as in the radiograph (766) and tracing diagram (767).



768

(10) ERECT—LATERAL

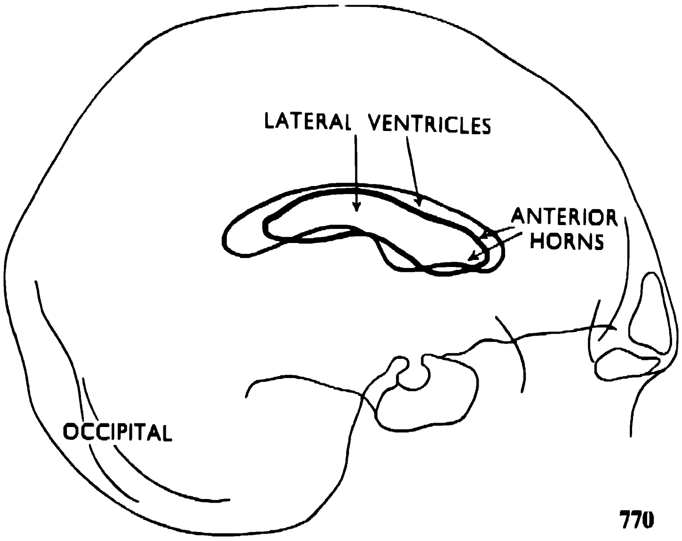
From the previous position the head is turned to the true lateral position, with the median line parallel, and the interorbital line at right angles, to the film.

CENTRE 2 inches above the external auditory meatus.
(768, 769, 770)

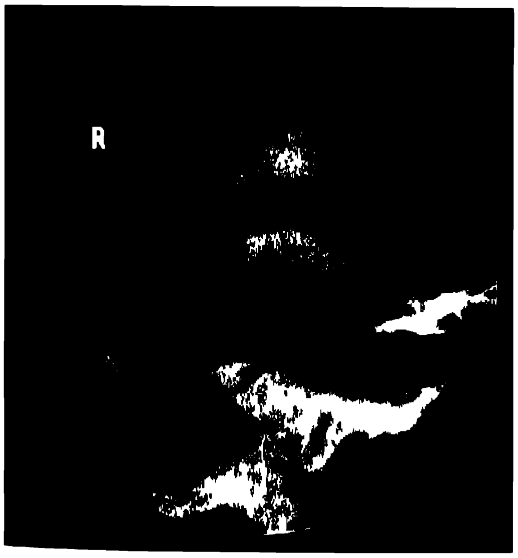
EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
58	42	25	28″	Ilford	Tungstate	Lysholm
60	70	43	36″	Ilford	Tungstate	Moving Potter-Bucky

Cone to size of film, 10 × 8 in or 12 × 10 in



770

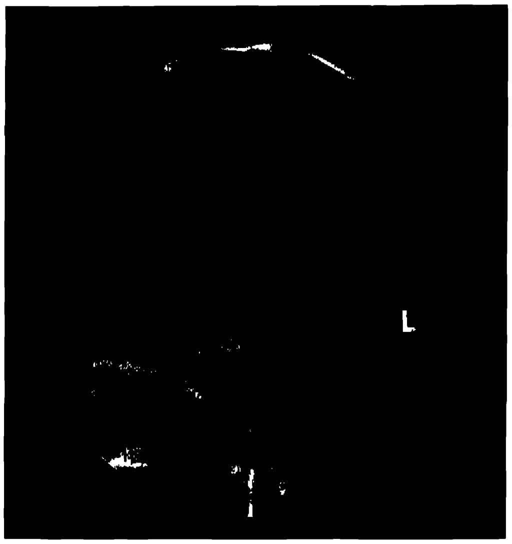


769

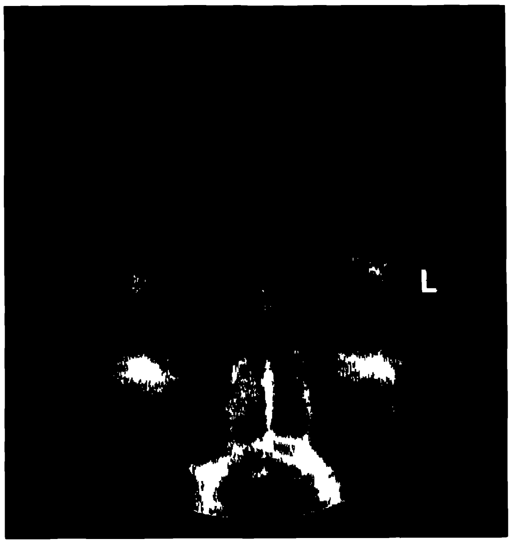
NOTE—This position shows the uppermost portions of the anterior horns and bodies of the lateral ventricles **(769, 770)**, and serves to confirm what the previous erect position may have shown.

Ventriculography and Encephalography

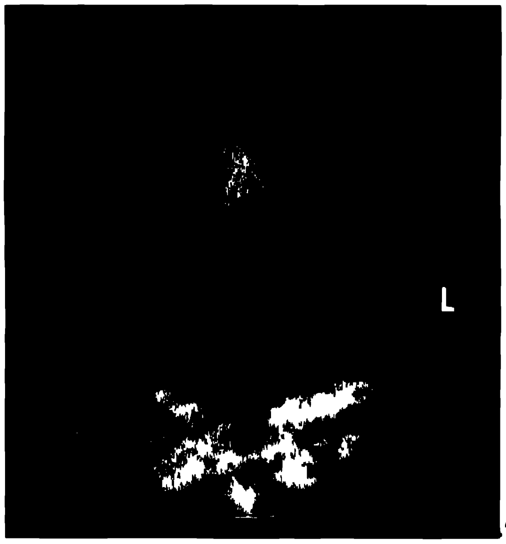
The radiographs resulting from the ten positions described and illustrated in this section are repeated on these two pages, with tabulated details of positioning and ventricles shown in order that comparisons may be facilitated. Radiographs (**747a, 756a** and **763a**) are placed in the positions occupied during exposure.



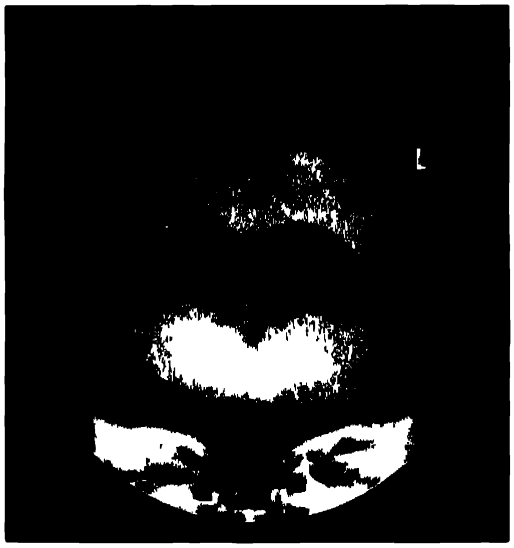
741a Supine



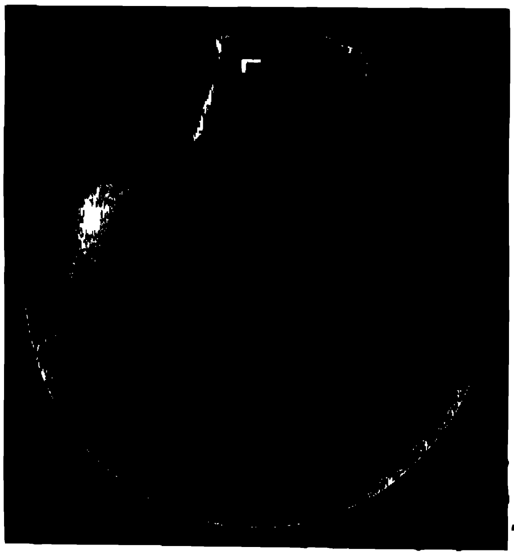
750a Prone



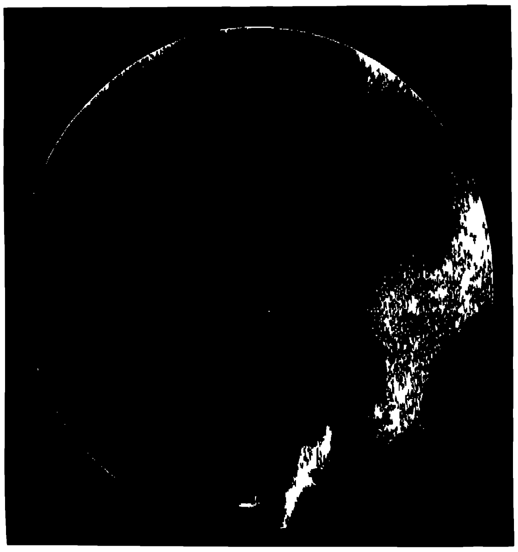
744a Supine



753a Prone



747a Supine

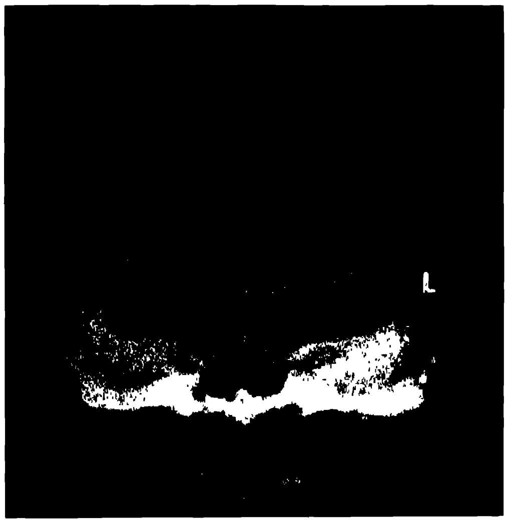


756a Prone

Ventriculography and Encephalography

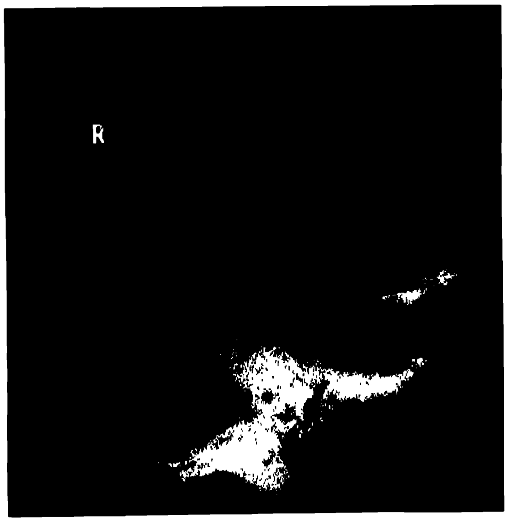
No.	Patient	Position	Tube	Ventricles shown
741a	Supine	Fronto-Occipital	Straight	Lateral—Anterior Horns and Bodies. Third.
744a	Supine	30° Fronto-Occipital	Angled 30°	Lateral—Anterior Horns and Bodies.
747a	Supine	Lateral	Horizontal	Lateral—Anterior Horns. Foramen of Monro. Third.
750a	Prone	Occipito-Frontal	Straight	Lateral—Posterior Horns.
753a	Prone	30° Occipito-Frontal	Angled 30°	Lateral—Posterior Horns. Third.
756a	Prone	Lateral	Horizontal	Lateral—Posterior Horns and Bodies.
759a	Lateral Right and Left	Lateral	Straight	Lateral—Foramen of Monro. Third. Aqueduct of Sylvius. Fourth.
763a	Supine Head Lowered	Lateral	Horizontal	Lateral—Anterior Horns. Foramen of Monro. Third. Aqueduct of Sylvius. Fourth.
766a	Vertical	Fronto-Occipital	Horizontal	Lateral—Anterior Horns and Bodies.
769a	Vertical	Lateral	Horizontal	Lateral—Upper portions of Anterior Horns and Bodies.

759a Lateral



766a Vertical

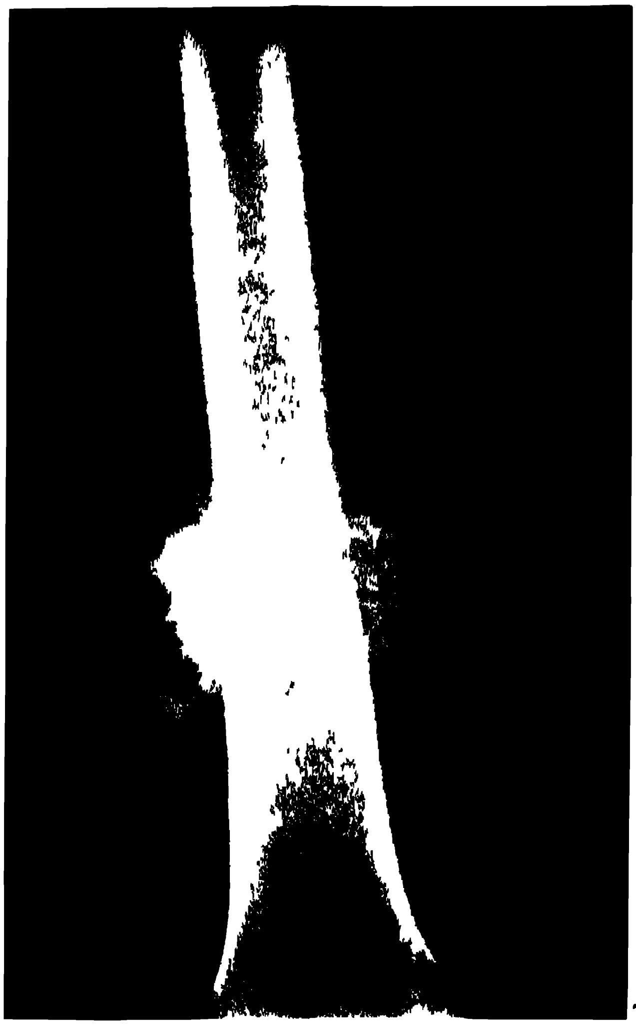
763a Supine Head Lowered



769a Vertical

SECTION 16

Arteriography



771

772

SECTION 16

ARTERIOGRAPHY

Arteriography is introduced at this stage as the radiographic positioning is similar to that already described for the skeleton.

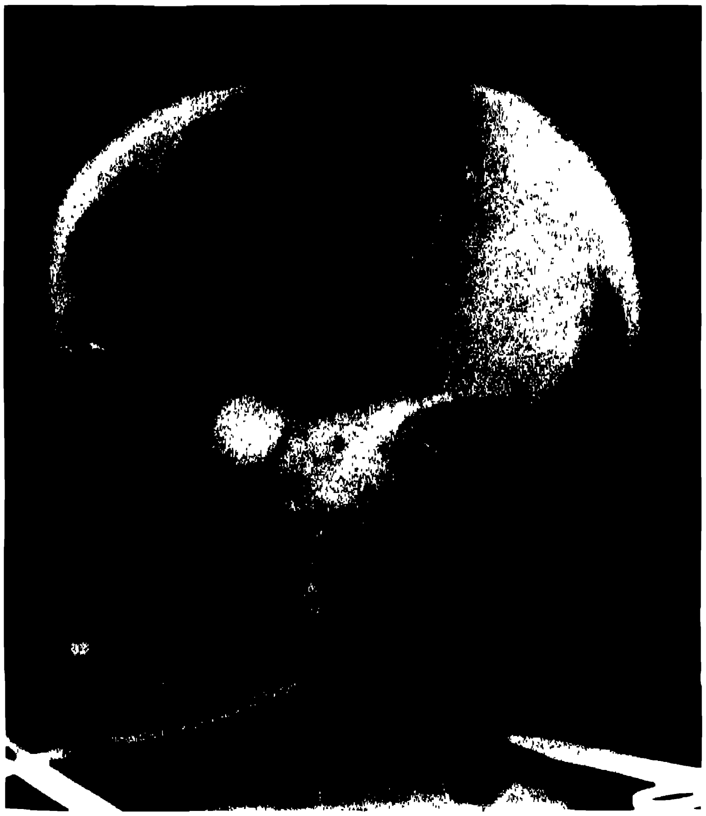
The arterial system is demonstrated radiographically by injecting the opaque medium *Thorotrast* into the regional main arteries—the brachial for the upper extremities, the femoral for the lower extremities, and the common carotid for the head.

Thorotrast is the trade name for a colloidal suspension of thorium dioxide, which is supplied in 12 cubic centimetre ampoules ready for immediate use.

EXTREMITIES

Arteriographs may be taken to show the arterial distribution within and around a new growth and, when operative measures are necessary, to assist in deciding the correct level for amputation. All should be in readiness for making the exposure before the injection is given, as the dye travels with great rapidity through the arterial system. The band of the sphygmomanometer (blood pressure apparatus) is applied above the site of injection and is inflated before the injection is made, and 15 cubic centimetres to 20 cubic centimetres of *Thorotrast* are then injected within a period of 5 seconds to 8 seconds, following which the first exposure is made and the band momentarily deflated to allow the pressure of blood to enforce a wider spread of the medium: the band is then reinflated and another exposure made. Antero-posterior and lateral views are taken as required, routine positions being employed. Two radiographs of the femur show the appearance before injection (**771**), and with the arterial system outlined after injection (**772**)—in this particular instance the injection having been made after amputation of the limb.

773



774

Arteriography

EXTREMITIES *(continued)*

Illustration (773) shows the arterial system of the lower leg and foot outlined following an injection of *Thorotrast.* A *positive*, in place of a *negative*, illustration has been used in this instance.

HEAD

Close collaboration between surgeon and radiographer is particularly desirable in cranial arteriography, where freedom of movement for the surgeon and speed of exposure following the injection are essential. The incision to disclose the common carotid artery is made in the operating theatre, but the actual injection of the *Thorotrast* is made in the X-ray department, with the patient's head already in the true lateral position on the cassette and the tube centred from above the couch. *The side to be examined is remote from the film* to render possible the injection of the *Thorotrast* to the carotid artery. The first exposure is made within two seconds of the injection being given and the X-ray examination, during which from three to five exposures may be made, should be completed *within fifteen seconds* of the injection, otherwise the venous system will also be shown and will obscure the arterial system. Lateral views are of chief importance: a lead and wood tunnel may be used to enable the series of films to be taken in rapid succession without moving the patient. Antero-posterior views may be included, but are not considered to be an essential part of the technique, especially in view of the short period in which the examination must be completed. The films are usually taken without the grid, as a short exposure technique is essential (774).

SECTION 17

Subject Types

SUBJECT TYPES

Experience will enable the X-ray worker to judge by the physique of the patient the probable location of the organs, especially those of the abdomen, and of these particularly the stomach, colon and gall bladder.

In the well-covered, large type of subject a comparatively small stomach placed high up under the diaphragm is to be anticipated. In this type the full length of the colon is seen, without overlapping of transverse and ascending and descending portions. The splenic flexure is high up under the left side of the diaphragm, and the hepatic flexure is at the level of the transpyloric plane **(878)**, page 332.

The gall bladder loses its well-known anatomical *pear* shape: it is seen end-on, and appears as a spherical body, being well supported in the horizontal, rather than the oblique, position. It is situated high up in the abdomen and well away from the mid-line. The thorax is short, but otherwise there is less variation in position to be considered radiographically than in the organs of the abdomen.

In the extremely thin subject the radiographer realises that to include the whole length of the stomach an extra large film will probably be required, to extend from the diaphragm to the symphysis pubis; and the whole of the colon may be shown within the shadow of the bony pelvis. In this type of patient the gall bladder appears to be elongated as, without support, it falls from the oblique to the vertical position, is low in the abdomen and nearer the mid-line, and may partially overshadow the fourth to fifth lumbar vertebræ. The thorax is usually long and narrow.

Needless to say, between these two extremes there are many intermediate types, and it is important to appreciate the possible variation in location of the organs in routine work, especially in gall bladder technique, when it is not usual to locate for position by fluorescent screen examination.

Four distinct types of "bodily habitus" are described by Mills, namely, Hypersthenic, Sthenic, Asthenic, and Hyposthenic. The following comments, together with the accompanying illustrations indicating the characteristics of chief radiographic importance in each type, are based on what are known as Mills's Subject Types, which have been modified to suit radiographic positioning.

Hypersthenic (1)

This type of subject is massively built; the thorax is broad from side to side, shallow from above downward, and deep from back to front. The lungs are correspondingly broad at the base and the apices barely show above the clavicles. The heart is broad and squat, with its long axis almost transverse.

The dome of the diaphragm is high, allowing great capacity in the abdominal cavity. The lower costal margin is at a high level and very near to the dome of the diaphragm. The stomach and colon are high up in the abdomen; the stomach empties well, and the whole of the colon is outlined without adjacent overshadowing. The gall bladder is almost horizontal in position, is high up in the abdomen and well away from the mid-line. This is not a common type, and does not exceed 5 per cent. of the community. **(775)**

Sthenic (2)

This is the commonest type, embracing 48 per cent. of the community. It is very similar to the hypersthenic type, but with general characteristics modified.

(776)

Asthenic (3)

The asthenic type is frail and of poor physique, with elongated narrow thorax; the lungs are correspondingly narrow and elongated, with the apices well above the clavicles. The heart is long and slender. The costal angle is less than a right-angle. The dome of the diaphragm is low in position, with the lower costal margin very near to the level of the iliac crests. The abdominal cavity is shallow, with the greatest capacity in the pelvic region. The stomach, in the erect position, is well down in the pelvis. The colon is low down and chiefly in the pelvis, doubling on itself so that radiographically the outline is difficult to distinguish. The emptying time for both stomach and colon is usually delayed.

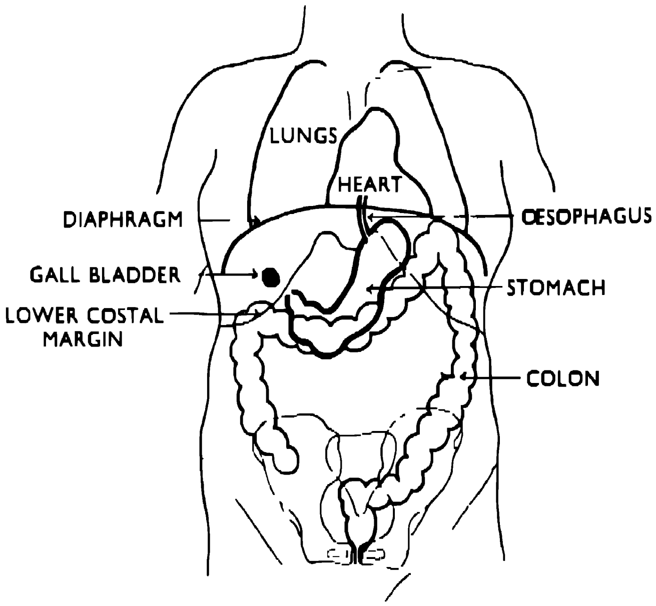
The gall bladder is almost vertical in position, is low down and very near to the mid-line. 12 per cent. of subjects fall within this type.

(777)

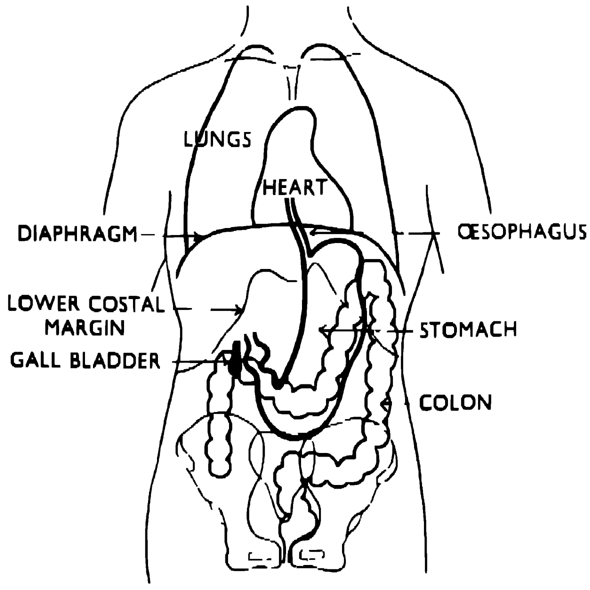
Hyposthenic (4)

These subjects are very similar to the asthenic, but have characteristics less marked, and embrace 35 per cent. of subjects.

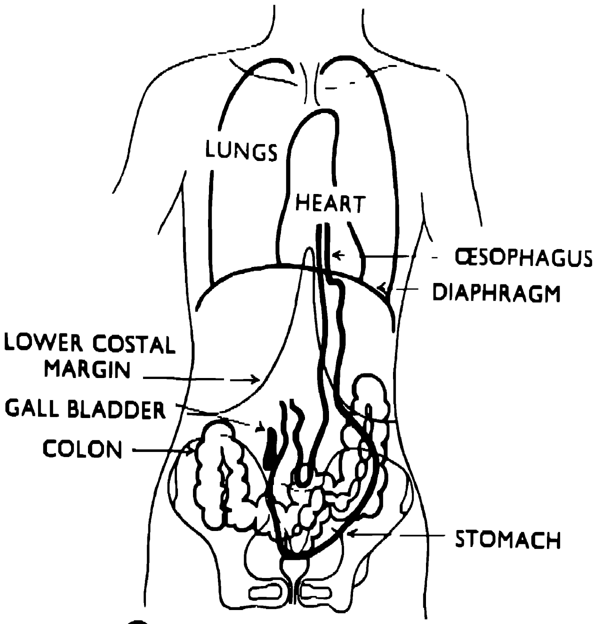
(778)



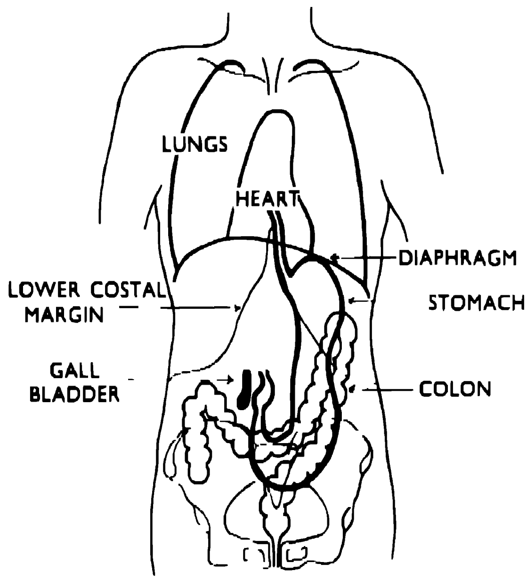
① HYPERSTHENIC 5% 775



② STHENIC 48% 776



③ ASTHENIC 12% 777



④ HYPOSTHENIC 35% 778

SECTION 18

Heart and Aorta

HEART AND AORTA

The *heart* is a hollow, muscular organ situated a little to the left of the mid-line in the anterior mediastinum, between the lungs, and resting on the dome of the diaphragm.

Radiographically the heart appears as a dense pear-shaped opacity, with the small end uppermost. It varies in appearance according to the build of the subject as referred to and shown diagrammatically in Section 17. There is also considerable variation in the appearance of the heart according to the position of the subject, whether erect or horizontal (**780, 781**), and to respiratory movements, whether quiet or forced.

When a high output unit is available a sharp outline of the heart may be obtained by an instantaneous exposure, with the patient breathing quietly, but when using a unit of medium output satisfactory results may only be obtained by an exposure of one-tenth of a second, made during arrested normal respiration. Additional exposures may also be required on forced respiration.

The cardiac cycle in the average subject occupies a period of eight-tenths of a second, and the complete cycle may be demonstrated on a single film by the use of the kymograph described in Section 19.

The *aorta* is the largest of the group of vessels which convey the blood from the heart to the various tissues of the body, and consists of three parts, the ascending portion, the arch, and the descending portion, this last, commencing at the level of the fourth dorsal vertebra, having an upper, or thoracic, and a lower, or abdominal, portion.

The thoracic aorta is best seen, radiographically, from the oblique aspects of the thorax, when the complete outline is shown from the upper part of the left ventricle of the heart to the diaphragm, which the thoracic aorta pierces to become the abdominal aorta. The posterior left portion of the arch is shown from the postero-anterior aspect as a small rounded protrusion slightly to the left of the spine and above the heart shadow.

The radiologist's fluorescent screen examination is an important part of the X-ray investigation of the heart and aorta. The patient is screened in the erect position from the antero-posterior, lateral, and right and left oblique aspects.

Variations in the outline of the œsophagus in relation to the heart and great vessels are also sometimes the subject of both screen and radiographic examination.

EXPOSURE TECHNIQUE

Radiographs of the chest to show the heart should be a little denser than those required for the lungs. Similar exposure factors are suitable, however, but at a slightly increased kilovoltage to secure greater density.

The 72 inch anode-film distance technique, necessary to show the exact size of the heart from the postero-anterior aspect, is referred to as teleradiography. For ordinary screen investigation a 24 inch anode-film distance is employed.

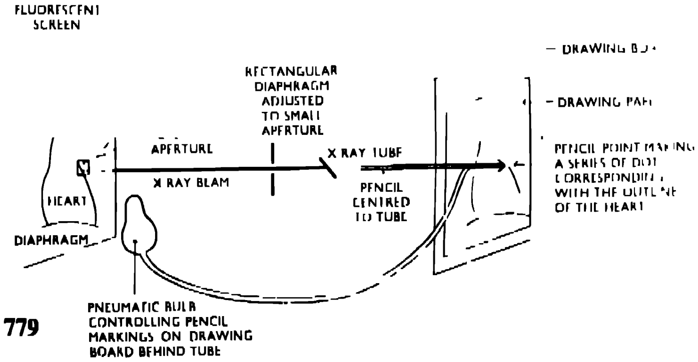
Two films of the same patient, exposed at 72 inches (**782**) and 30 inches (**783**), respectively, show the variation in the size of the radiographic image according to anode-film distance.

For oblique views a 36 inch anode-film distance is used to secure projection separation of the heart and spine shadows.

As an alternative to teleradiography, especially when the X-ray unit does not permit of the high output required for a 72 inch anode-film distance, the orthodiagraph may be used to record the size of the heart, a short anode-film distance being employed.

ORTHODIAGRAPH

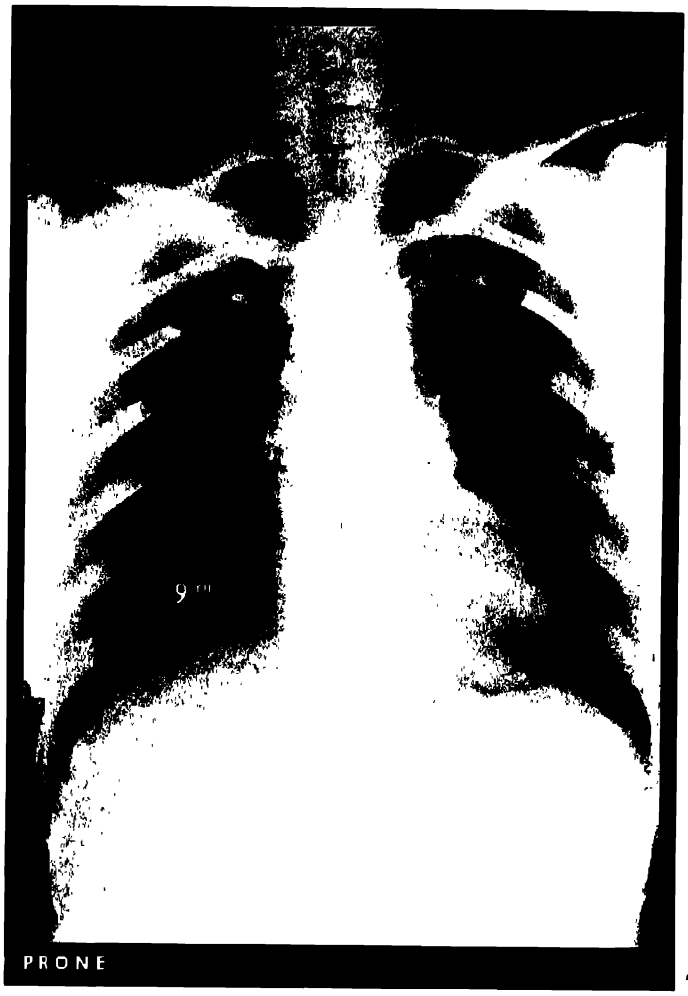
The orthodiagraph consists of a board, with drawing paper attached as required, fixed to the back of the screening stand. A remotely actuated pencil, controlled by a pneumatic compressor bulb, is fitted to the back of the tube support and adjusted to coincide and to move with the focal spot of the X-ray tube, marks made by the pencil on the drawing paper being controlled by the operator to accord with the shadows seen on the fluorescent screen.



779

The patient is placed with the anterior chest wall in contact with the screen, and is told to breathe quietly without moving the trunk. After screening to

780



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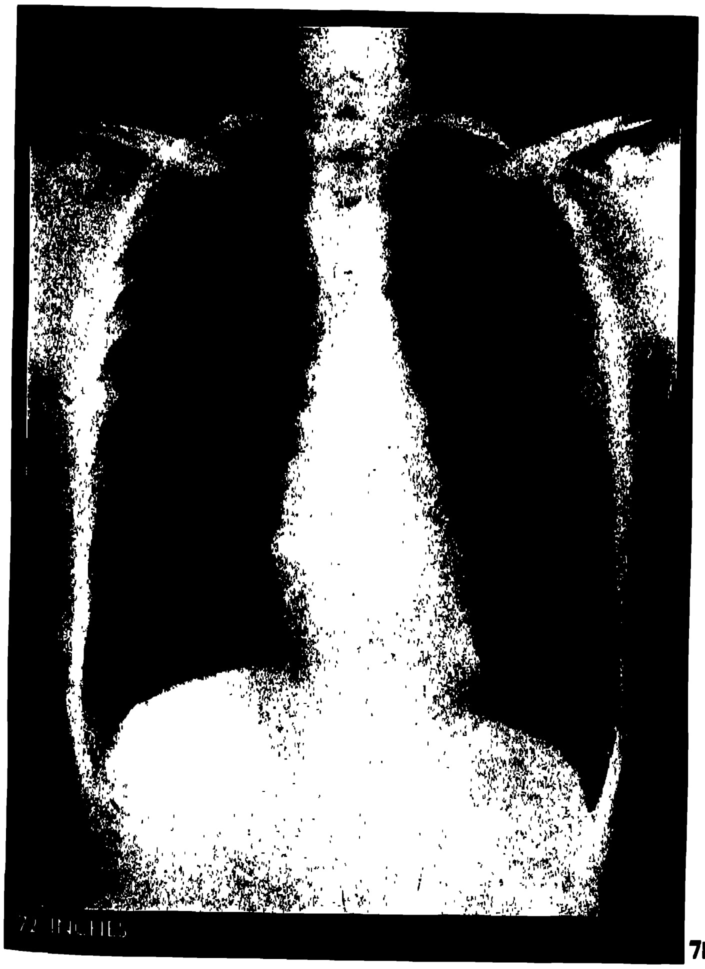

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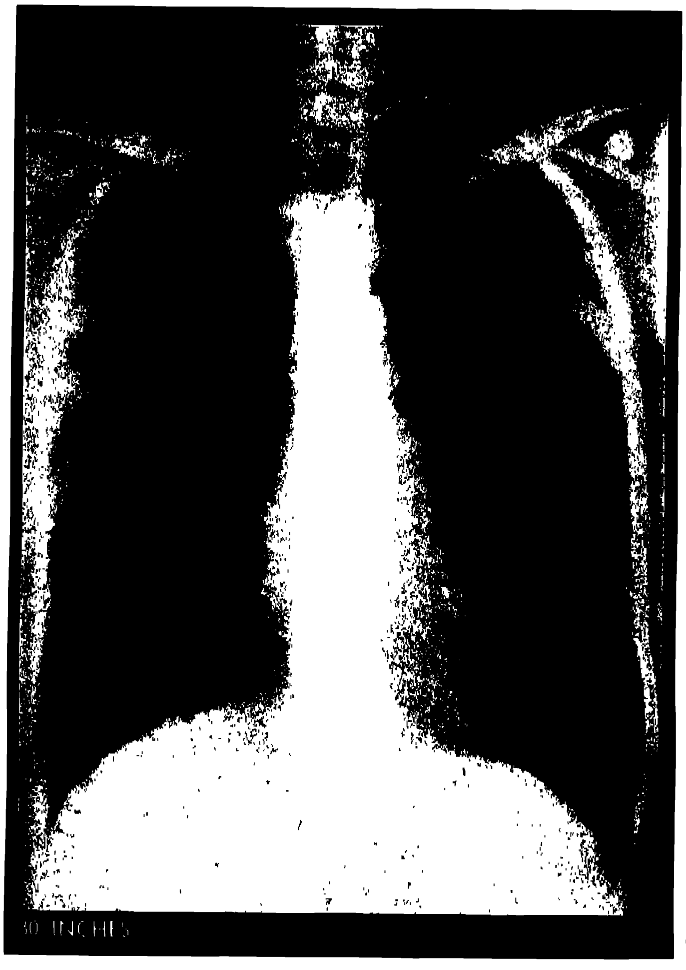

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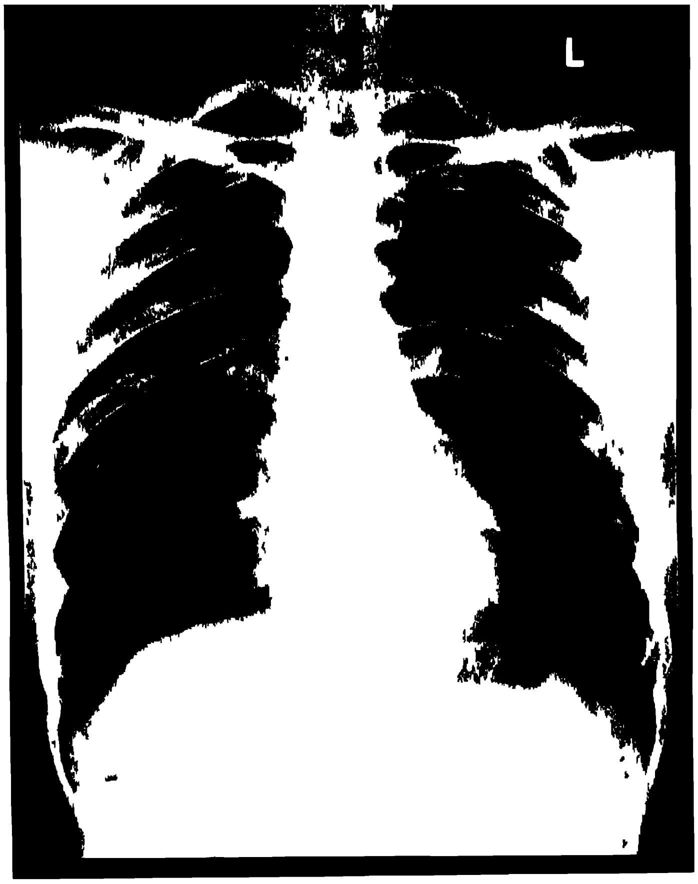


785

ORTHODIAGRAPH *(continued)*

locate the heart shadow the aperture is reduced until only a very small part of the heart outline is left visible. The beam of light is then moved to follow the outline of the heart on the screen, and at each movement the paper is marked with the pencil, the result being a complete series of dots which, joined up, give a diagrammatic representation of the actual size of the heart. The relationship between fluorescent screen, subject, X-ray tube, pencil and paper is shown in diagram (779) on page 290.

Another method is to mark a similar series of dots on cellophane attached to the front of the screen or to mark directly on to the protective lead glass, using a dermatographic or a glass pencil; and while there is much to be said for the use of the orthodiagraph, this latter method, when reasonable care is used, yields results which are adequate in the majority of cases.

The exposure factors quoted in this section refer to an adult male subject having a thickness through the chest, on inspiration, of 8½ inches from anterior to posterior, and from side to side, at the level of the axilla, of 11½ inches.

POSTERO-ANTERIOR

The patient is placed facing the film, with the arms encircling the cassette and with the chin over the top edge of the cassette to ensure close proximity of heart and film.

CENTRE the tube to the level of the sixth dorsal vertebra.

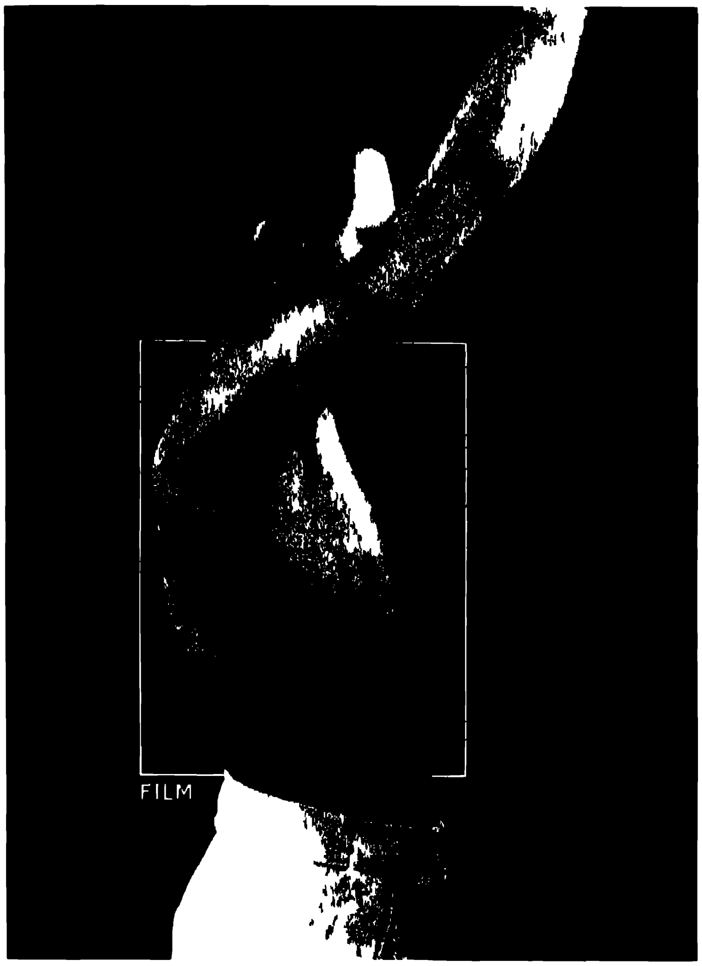
Exposure is normally made with the patient breathing quietly, but with apparatus of limited output it may be necessary to make the exposure during arrested respiration. (784, 785)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	35	20	72″	Ilford	Tungstate	—
65	18	15	72″	Ilford	Fluorazure	—

Cone to size of film, 15 × 12 in.

It is important that a perfectly symmetrical view of the thorax should be obtained. Rotation of the trunk to right or left sides, recognised in the radiograph by the asymmetrical appearance of the clavicles, will give rise to a distorted position and view of the heart. Reference should be made to illustration (808), Section 20.



786

787

Heart and Aorta

HEART-LATERAL

The patient is turned to bring the left side toward the film, with the arms folded over the head, or raised above the head to rest on a horizontal bar support, as shown in the illustration

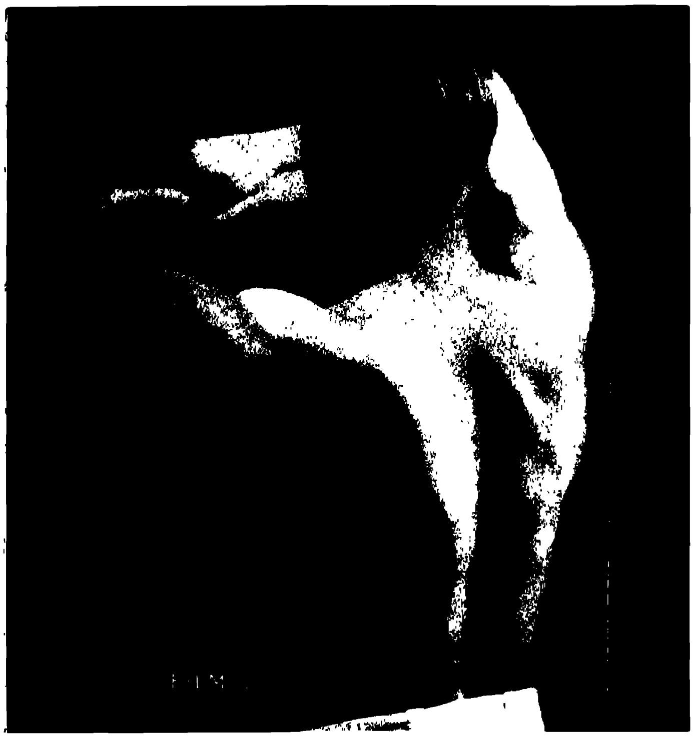
CENTRE the tube to the axilla, at the level of the sixth dorsal vertebra

(786, 787)

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
90	25	20	72	Ilford	Tungstate	
85	25	20	72	Ilford	Fluorazure	

Cone to size of film 15 12 in

For the lateral position it is necessary to increase the kilovoltage considerably to allow for the thickness of the subject from this aspect An undistorted view of the heart is required, necessitating an anode-film distance of 72 inches, and a minimum increase of 20 kilovolts is therefore usually applied Limited tube output, however, may necessitate the employment of a reduced anode-film distance



788

Heart and Aorta

OBLIQUE

It is essential to screen each patient to obtain the individually correct oblique position, this being reached when the maximum clear space is seen between the heart and spine. The angle of rotation of the trunk may vary from subject to subject by as much as 15 degrees, the average angle in relation to the postero-anterior position being 60 degrees for the right oblique and 70 degrees for the left oblique (789, 793).

The anode-film distance should be reduced from 72 inches to 36 inches to allow projection separation of the heart, aorta, and spine.

RIGHT OBLIQUE

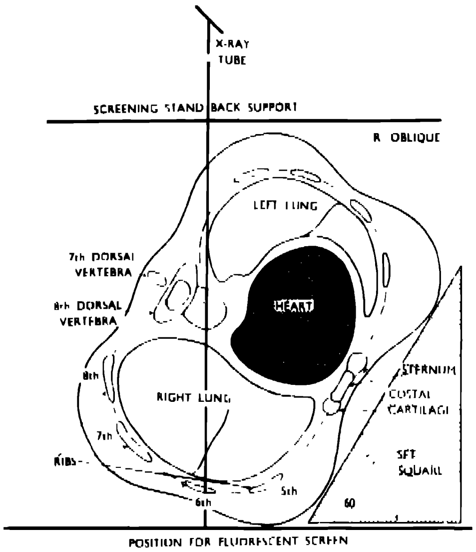
During the screen examination the patient is turned with the *left* side away from the screen until a clear space is seen between the posterior border of the heart and the spine. In this position the transverse plane of the trunk may be at an angle of 55 degrees to 60 degrees to the screen.

CENTRE to show the heart, aorta, and œsophagus.

(788, 789, 790, 791)

Exposure factors are given on the next page.

The tracing diagram (791) is included to assist in showing the location of the various regions of interest and their relative positions in this view.



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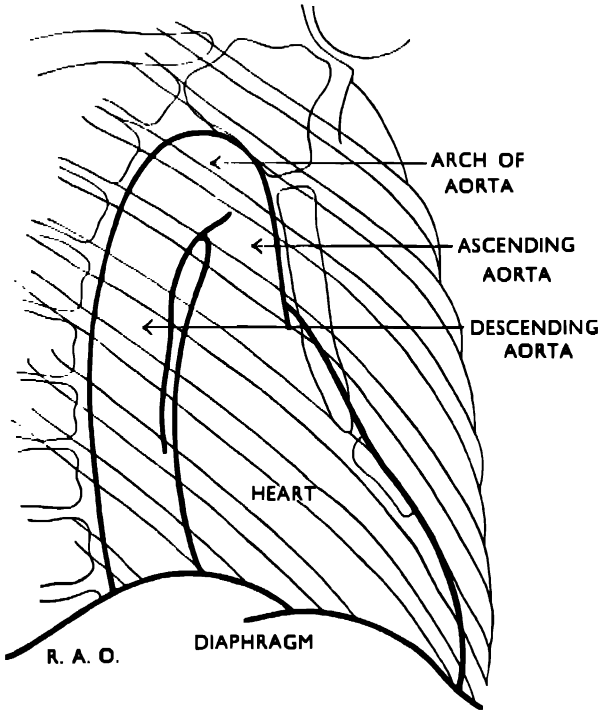


791

792

Heart and Aorta

LEFT OBLIQUE

The patient is turned in the opposite direction, with the *right* shoulder away from the screen, until the maximum clear space is seen between the heart and spine There is frequently overshadowing of the broadest section of the heart and the spine, which may sometimes be avoided when the degree of rotation is greater than for the right oblique view

CENTRE to show the heart, aorta, and œsophagus
(792, 793, 794, 795)

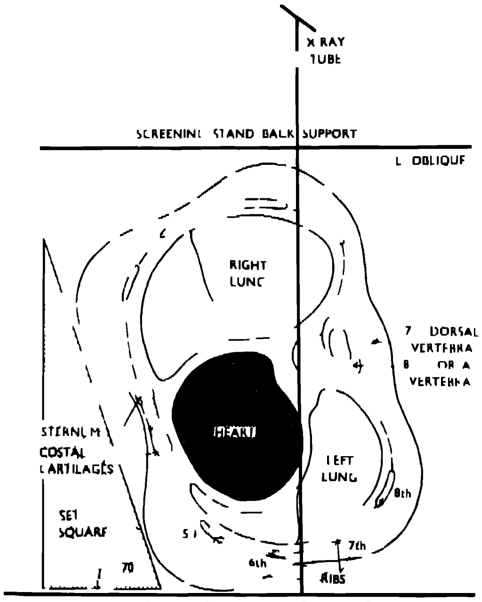
EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	35	20	36	Ilford	Tungstate	—
65	16	10	36″	Ilford	Fluorazure	—

Cone to size of film, 15 12 in

Comparison should be made between the right and left oblique positions as shown in the radiographs and tracing diagrams

The cross-sectional plan diagrams (789, 793) are included to show the relationship between X-ray tube, patient, and film, and also the method of applying the angle by means of a set square when the films are exposed at an interval following, and apart from, the screen examination



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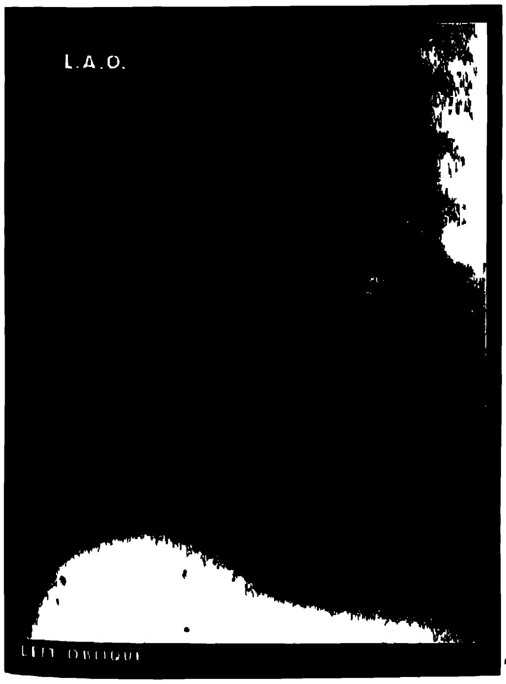

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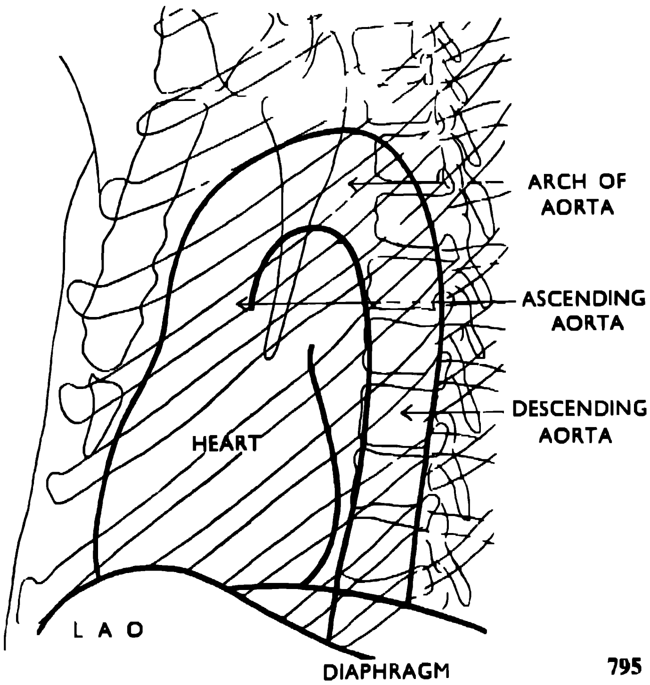


795

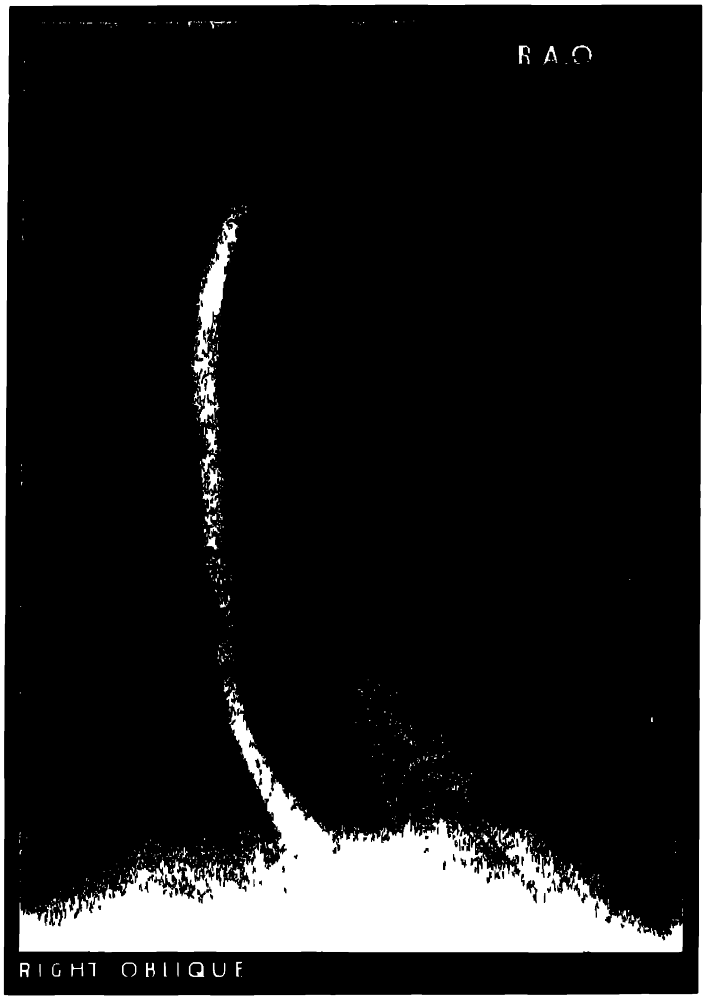
Heart and Aorta

ŒSOPHAGEAL MEAL

An abnormal condition of the heart may give rise to variation in the outline of the œsophagus in relation to the heart, and the œsophagus is therefore frequently the subject of both screen and radiographic examination in the investigation of heart abnormality.

An œsophageal meal is prepared: this should be thick enough to adhere to the walls of the œsophagus, and is given during the visual screen examination, the patient being viewed in antero-posterior and right and left oblique positions. Films are exposed as required, with the patient in the positions described and illustrated in the foregoing pages.

(796, 797, 798)



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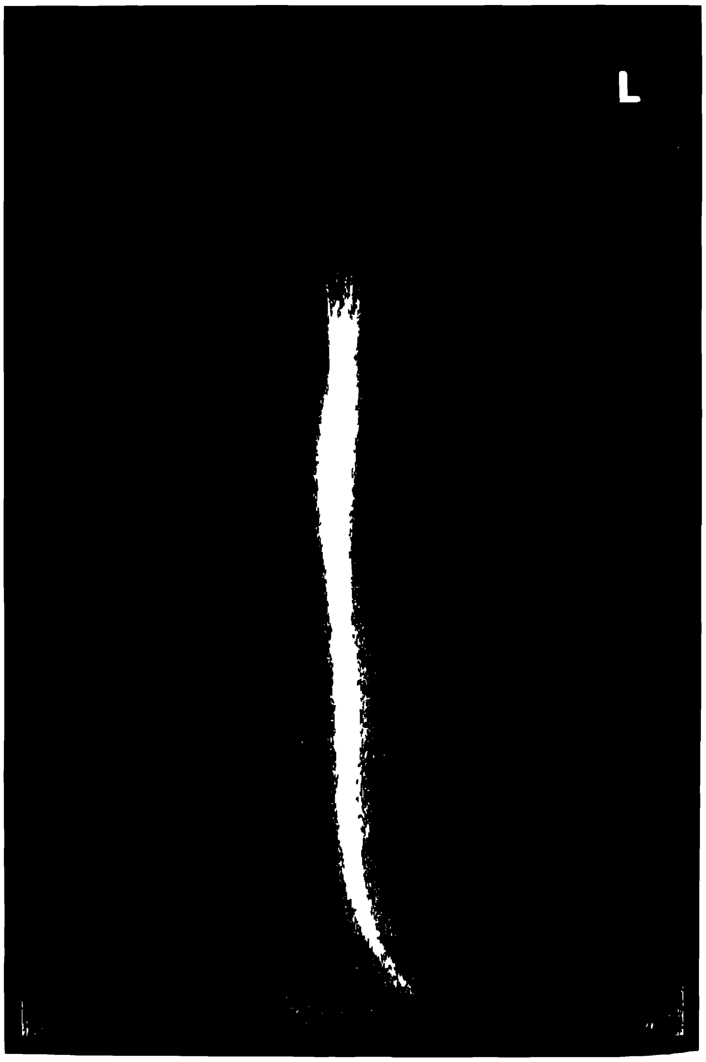
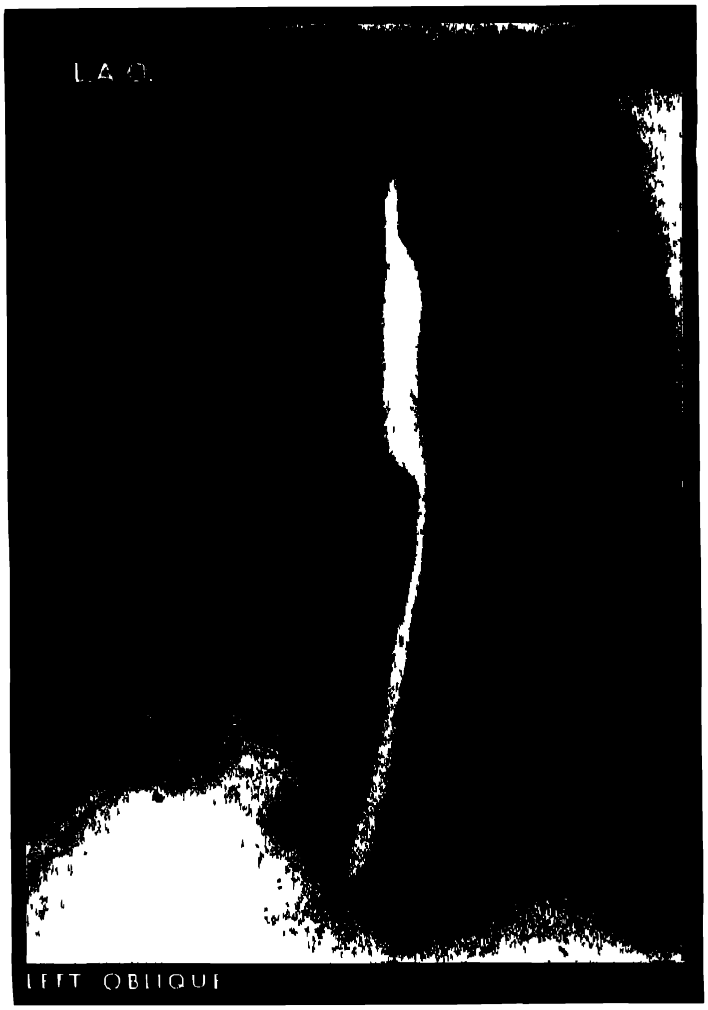




797

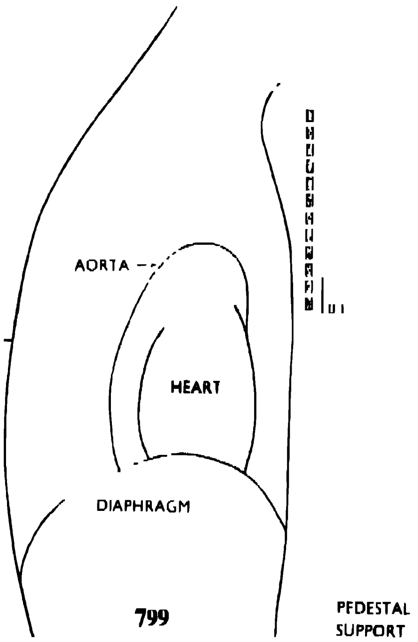
SECTION 19

Kymography

KYMOGRAPHY

Kymography is the term used to describe the method of radiographically recording movement occurring in certain organs, such as the heart and alimentary and renal tracts.

The apparatus used consists of a grid mounted in a frame which has a space also for the film cassette **(799)**, grid and film being so arranged that either may remain stationary while movement is applied to the other, timing of the movement being automatically operated by connection with the X-ray exposure switch.



799

The grid is made of parallel strips of lead of equal width which are spaced 0·4 millimetre apart. The strips may be from 9 millimetres to 12 millimetres wide, a width of 10 millimetres being referred to for the present purpose.

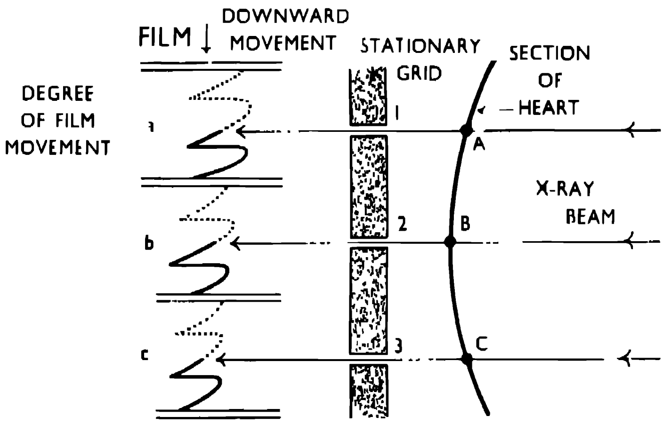
In the examination of the organs having the slower movements an alternative grid having 18 millimetre strips may be used.

The *extent* of the movement of the grid or film is the same as, or slightly less than, the width of a single grid strip—for the present purpose 10 millimetres.

The *time* occupied by the movement, which varies according to the region under examination, is equivalent to the X-ray exposure time. A selection of exposure factors for heart, pharynx and œsophagus is given later, and it should be noted that for the longer exposure times the milliamperage is reduced to enable the exposure to be within the rated capacity of the X-ray tube.

MOVING FILM—STATIONARY GRID

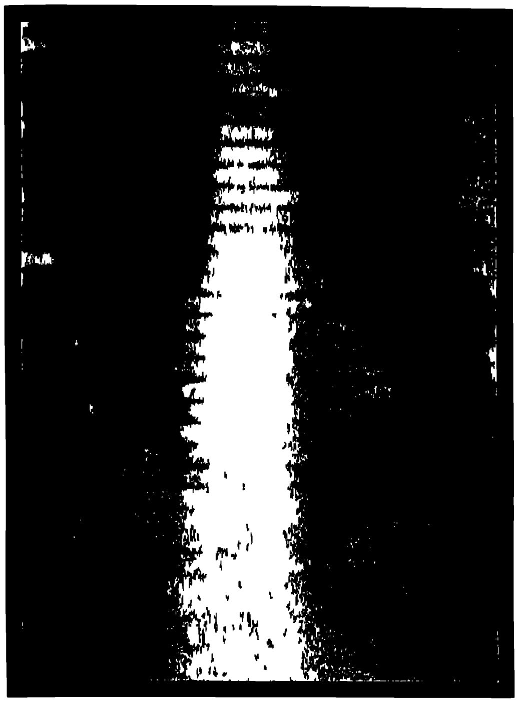
At each instant of the exposure time a separate image is recorded on the film as it moves over the grid apertures. Thus the resulting "kymograph," as it is called, is made up of a series of images following one another in rapid succession and recording the continuous movement of the organ at points 10 millimetres apart in a series of strips on the film, each 10 millimetre strip of film showing a number of 0·4 millimetre wide exposures of the organ surface and recording its movement at that particular point during the total exposure period.



HEART SPOTS A B C ARE SHOWN THROUGH GRID SLOTS 1 2 3 ON CORRESPONDING FILM AREAS a b c.

800

Diagram **(800)** shows a small section of heart, grid and film, and also the procession of impressions received by each section of the moving film as it passes the grid apertures through which the X-ray beam projects the shadow of the small section of heart, more than two complete cardiac cycles being shown during a 2 second exposure. The resulting kymograph is shown in **(801)**.



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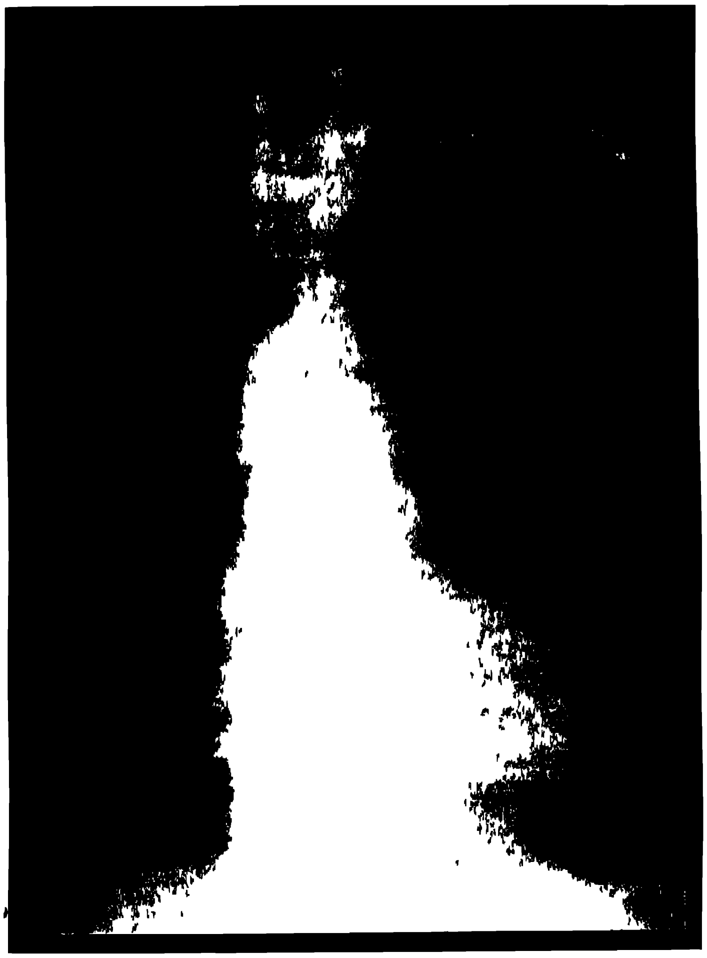


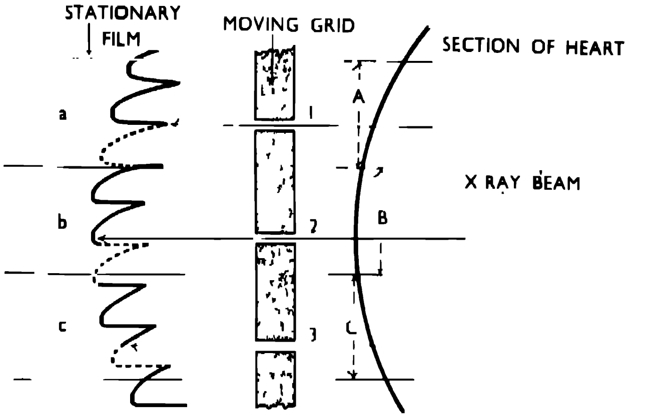
801a

Kymography

MOVING GRID—STATIONARY FILM

As in this case the *grid* moves in relation to the surface of the organ, the film receives a series of images showing transverse movement over areas having the width of the space between the grid apertures, that is, 10 millimetres.

Diagram (**802**) shows the relationship between a small section of the heart surface and the X-ray beam, moving grid and stationary film.



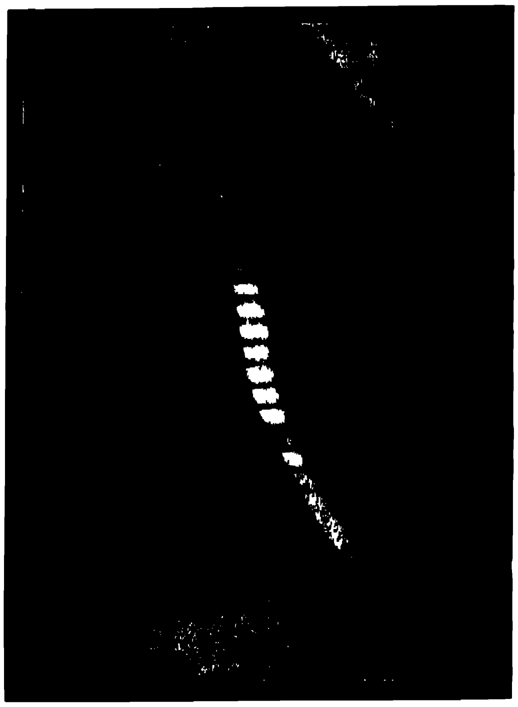
HEART AREAS A B C ARE SHOWN THROUGH MOVING GRID SLOTS 1 2 3 ON CORRESPONDING FILM AREAS a b c

802

Illustration (**801a**) is a typical kymograph of a normal subject. It will be seen that the wave-form varies for each section of the heart and great vessels—auricles, ventricles, and aorta.

The period occupied by the movement of the heart during the cardiac cycle, from contraction in systole to maximum distension in diastole, in the normal subject occupies a period of $\frac{8}{10}$ second, and it will be seen in the radiograph (**801a**), which was exposed for 2 seconds, that $2\frac{1}{2}$ cardiac cycles are recorded through each grid slot. On joining the troughs of the waves the heart is seen at its minimum size in systole, the line joining the crests indicating its maximum size in diastole.

Respiration should be arrested during the exposure, and as the heart movement differs on inspiration and expiration, respiratory conditions at the time of the exposure should be recorded.



803

Kymography

It should be noted that the slower the movement of the organ the longer should be the exposure and, therefore, correspondingly, the slower the grid travel.

Illustration (803) is a kymograph of the œsophagus showing transverse movement as seen from the right anterior oblique aspect.

Region	kVp	mA.	Secs.	Distance
Heart	76	80	2	48″
Pharynx	80	80	1½	36″
Œsophagus	90	60	3	36″

Blue Label Developer. Ilford Tungstate Screens

Kymoscopy denotes the viewing, by means of fluorescent screen and kymographic grid, of the actual movement of the organ under examination.

In a kymoscopic viewing box a radiograph of the kymographic grid is placed over the actual kymograph of the organ examined, and by a simple mechanism the one moves over the other to show very realistically the movement of the organ during the actual exposure.

SECTION 20

Respiratory System

RESPIRATORY SYSTEM

The respiratory system consists of the nose, pharynx, larynx, trachea, bronchi, lungs, and pleuræ. This section deals with the organs of chief radiographic importance, namely, the trachea, bronchi, and lungs.

The thymus gland, situated in the upper part of the mediastinum, is also included in this section as the technique is similar to that required for the lungs.

The *Trachea* is a cartilaginous and musculomembranous tube descending from the larynx to the bronchi. It commences at the cricoid cartilage, on a level with the sixth cervical vertebra, and normally ends at the level of the fifth dorsal vertebra, where it divides into a right and a left bronchus. It is located anterior to the œsophagus, in the neck and upper thorax.

The *Bronchi* descend from the termination of the trachea, each toward the hilum of the corresponding lung. The structure of the bronchi is the same as that of the trachea.

The *Lungs* are the organs of respiration. They are covered by a serous coat, called the pleura, and each lung, the right and the left, lies within its pleural cavity, between the lungs being the mediastinum, containing the heart and other mediastinal structures. The right lung, which is slightly larger than the left, has three lobes; it is also shorter and wider than the left lung, due partly to the bulk of the right lobe of the liver pressing the right side of the diaphragm to a higher level than the left side, and partly to the heart and pericardium lying a little to the left of the mid-line. The left lung has two lobes, and in the anterior border is the cardiac notch, which lies in contact with the left ventricle of the heart.

The *Mediastinum* is the middle space between the lungs, containing the heart and great vessels, the œsophagus, trachea, and bronchi. It extends from the sternum to the vertebræ, and from the upper thorax to the diaphragm.

The *Diaphragm*, as its function is of great importance in radiography of the lungs, is discussed in this section. It is the musculomembranous partition separating the thorax from the abdomen. The superior surface, which forms the floor of the thoracic cavity, is convex, rising to a higher level on the right side as compared with the left; the inferior surface, which is concave, forms the roof of the abdominal cavity. The upper level of the dome of the diaphragm varies, reaching its lowest level on inspiration and its highest on expiration, and is higher in the body when the latter is in the horizontal position than when in the erect, owing to pressure by the abdominal organs.

RESPIRATION

Respiratory movements are of great importance in lung technique. When the lungs are filled with air they are more translucent radiographically, and give a brighter picture both on fluorescent screen and film. On full inspiration the diaphragm is depressed, so that the greatest area of lung tissue is visible **(805)**, but on expiration the diaphragm rises to its highest level, obscuring a very considerable area of the lung **(806)**. Unless circumstances indicate otherwise, the X-ray exposure is made at the end of normal inspiration, and the importance of *normal full inspiration* as distinct from *forced* or *partial* inspiration cannot be too greatly stressed.

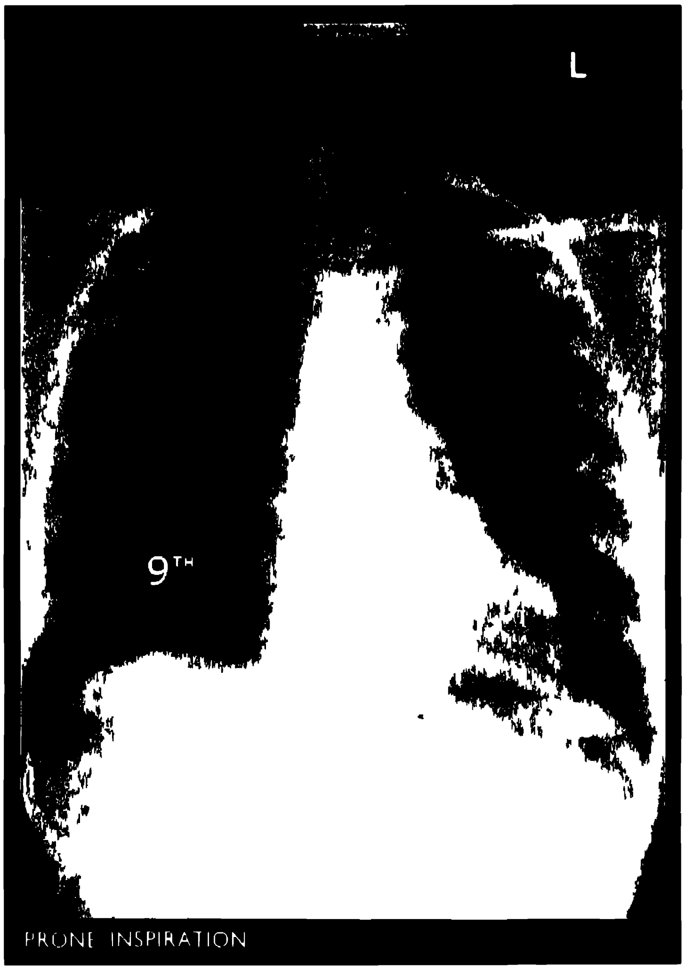
A brief explanation to the patient, with a rehearsal of the procedure, should ensure a satisfactory result. The cycle of respiratory movements may be repeated several times before the performance is considered to be satisfactory, and, the patient having taken a deep breath, a few moments should be allowed to elapse to enable him to become sufficiently steady to prevent movement. Risk of movement is, of course, minimised by the use of the modern unit, which makes possible exposures within the region of 1/100th to 1/30th of a second.

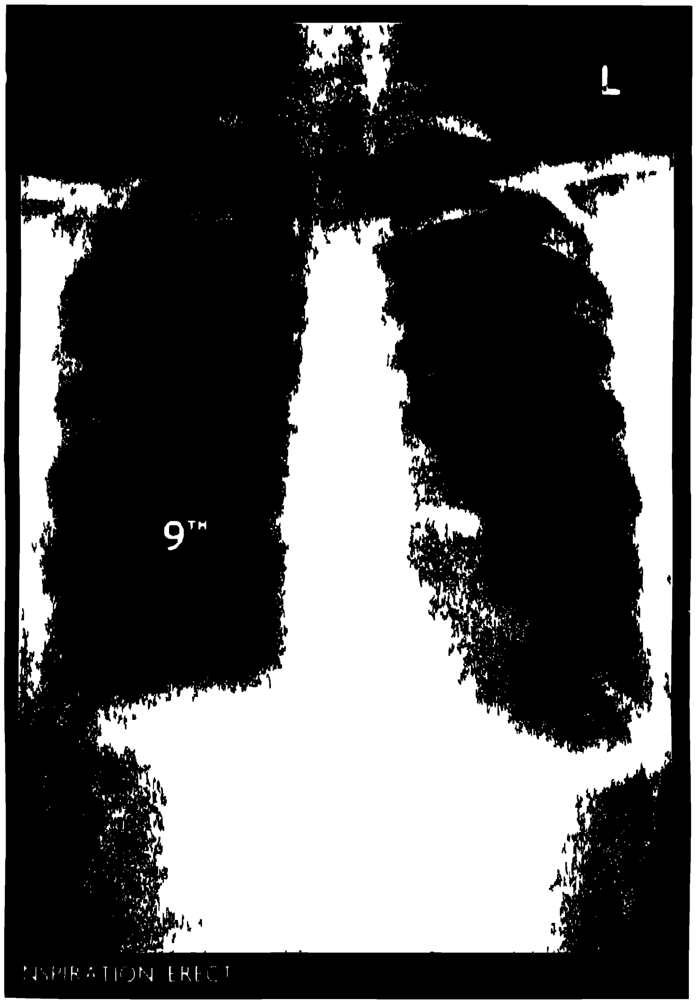
On inspiration there is always a tendency to raise the shoulders, which should be avoided, as the shadows of the clavicles then obscure the lung apices.

ERECT OR HORIZONTAL

The choice of erect or horizontal technique is governed chiefly by the condition of the patient, but erect technique is to be preferred when it can be applied, and the following comments on these positions should be noted. In the erect, positioning of the patient is simplified, control of respiration is more satisfactory, the gravity effect on the organs allows for the disclosure of the maximum area of lung tissue, and fluid levels are readily shown, although it should be possible, with forethought in positioning the patient, to demonstrate fluid levels also in the horizontal position.

Heavy breast shadows, however, are not easily diffused, immobilisation and lung-film proximity is less satisfactory, and the erect position is not possible for bedridden patients. Comparison should be made of **(804)** with **(805)**, exposed, respectively, with the patient in the prone and in the erect positions.


L
9TH
PRONE INSPIRATION
804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9TH
INSPIRATION ERECT
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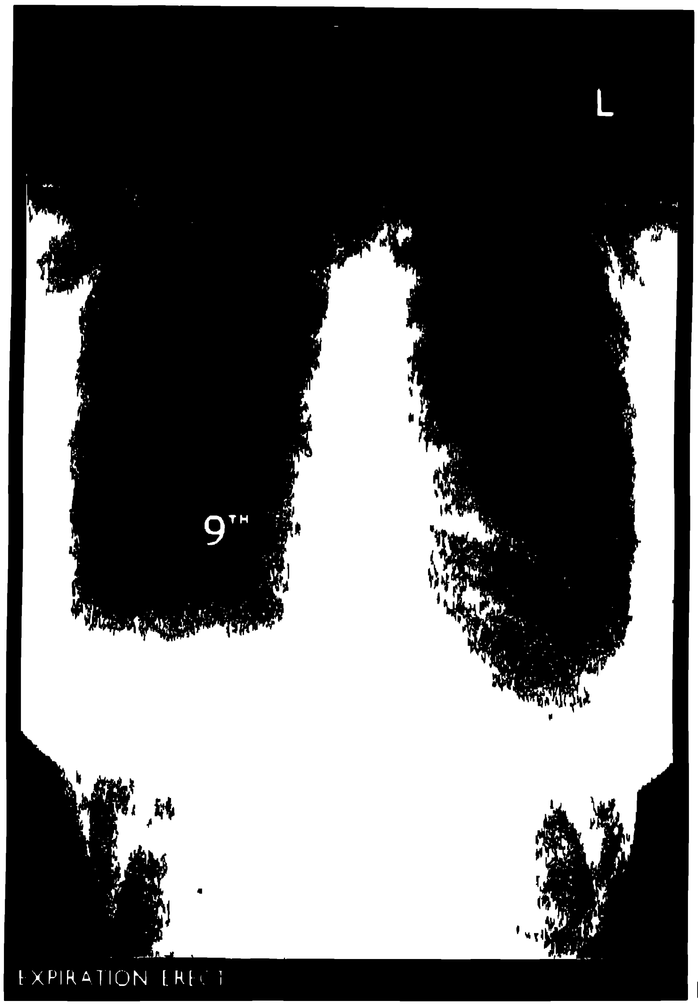
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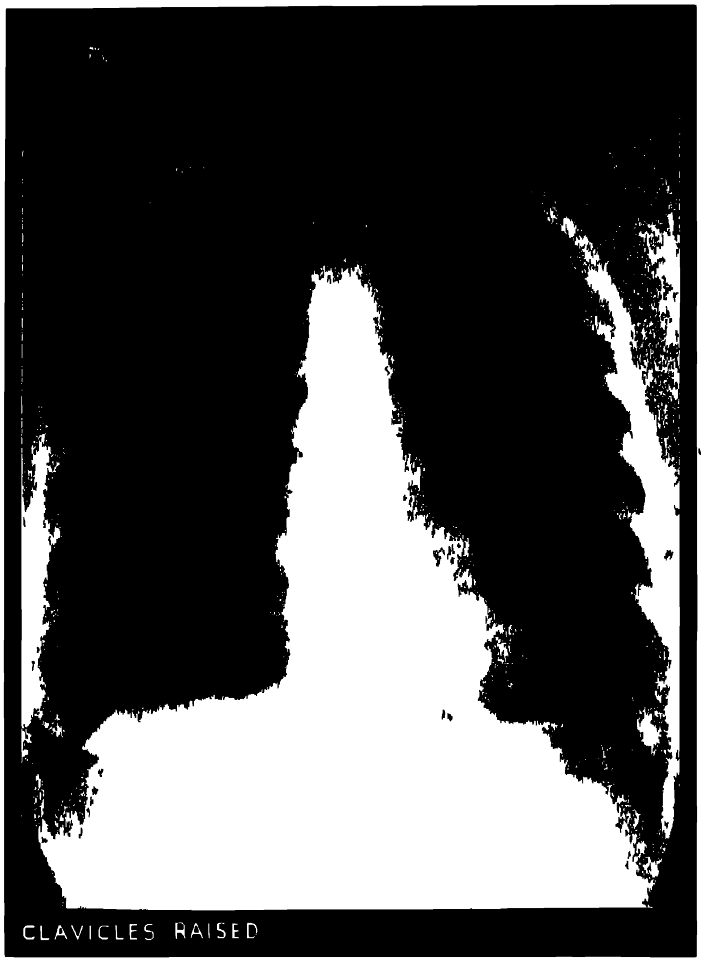


807

808

POSTERO-ANTERIOR OR ANTERO-POSTERIOR

The postero-anterior position is most generally adopted, as, at the greater anode-film distances, the arms can be more easily arranged to enable the shadows of the scapulæ to be projected beyond the shadows of the lung fields. At the shorter distances, too, the thinner anterior chest wall allows the lungs to be nearer to the film, and the nearness of the heart to the film minimises its lung-obscuring film shadow.

SCREENING

Diagnostic screen examinations are made by the radiologist, but the radiographer is sometimes expected to work the controls. It should be noted that comparison of apices, hilar shadows and diaphragm movements are made through a narrow transverse slit on inspiration and expiration; for general comparison of the two sides an open field is used; for the mediastinum a narrow, vertical aperture is used, with the patient rotated obliquely to right and left sides in turn; for fluid levels the patient may be required to bend from the waist to right or left side.

During the screen examination the radiologist also decides as to the necessity for taking oblique or lateral views, oblique views being taken to show the mediastinum and lateral views to enable gross lesions to be located.

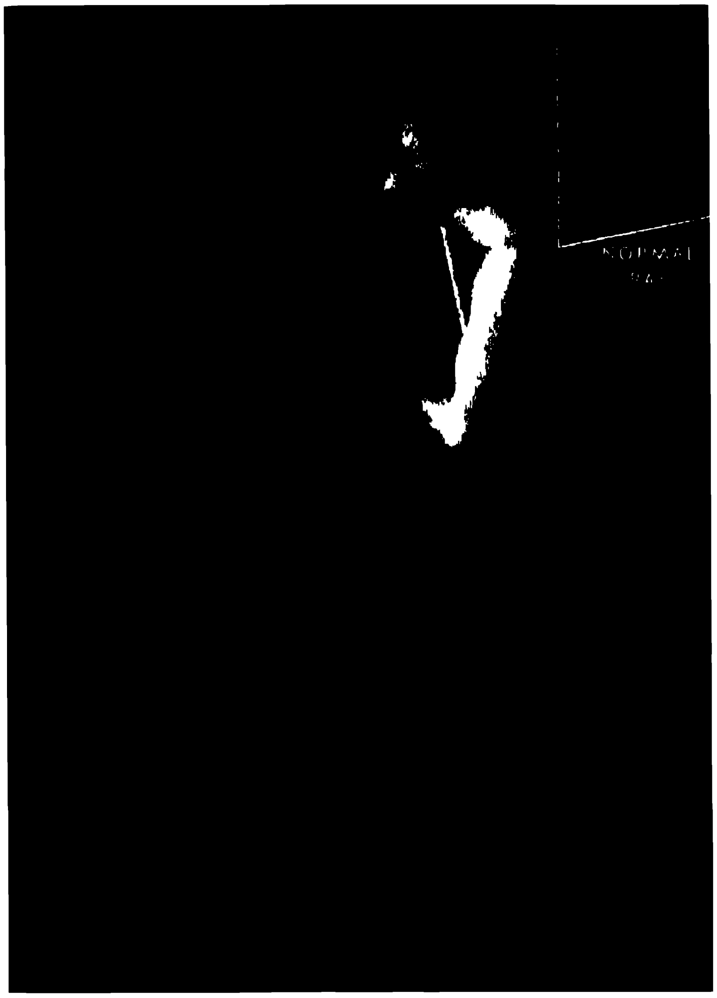
Where screening is not possible, and it is important that the excursion of the diaphragm should be observed, radiographs are taken, one at the end of deep inspiration and one at the end of expiration.

Screen examinations by the radiographer are for adjustment of position for a following radiographic exposure.

Exposure conditions for screening are 80 kilovolts to 90 kilovolts, 3 milliamperes to 7 milliamperes, and 24 inches to 28 inches anode-film distance.

FILM SUPPORT

Every screening stand does not permit of the correct positioning of the patient for chest work: it is essential that the chin be allowed to rest over the top edge of the cassette, or cassette support, in order to bring the apices close to the film, and preferable for the arms to encircle the film so that the scapulæ are projected, laterally, clear of the lungs. In clasping the cassette, the elbows, and consequently the shoulders, are kept well down to prevent the clavicles from obscuring the apices of the lungs (**807**). When the film support is too broad to allow the arms to encircle it the backs of the hands are placed behind the hips, with the elbows flexed and the shoulders well down and forward. When the stand does not allow room for



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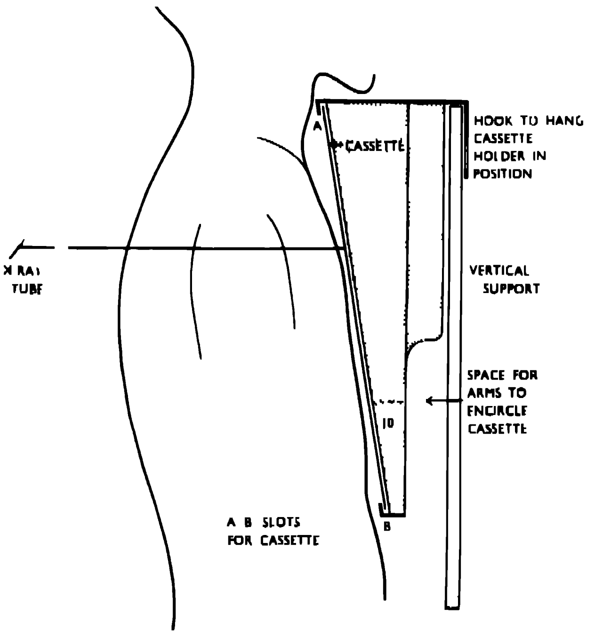


810

FILM SUPPORT (*continued*)

the flexed elbows, the arms should be placed beside the trunk and the arms rotated forward. Some workers consider it to be an advantage for the cassette to be angled 10 degrees from the vertical, toward the apices **(810)**.

Teleradiography has led to many improvised film supports, and it is sometimes difficult to centre correctly when the couch tube is used to project the beam horizontally from a variable position. It is helpful to make a permanent line, 72 inches long, on the floor between tube and film support, calibrated at the tube end, at every 6 inches between 42 inches to 72 inches. A 60-inch rod with a tape measure attached serves to adjust the height of the tube to the centring point required.

BEDSIDE FILM SUPPORT

A simple chest rest, particularly adaptable for the sick patient in the ward, has been devised. It consists merely of a prop 56 inches in length, having a pointed ferrule at one end to prevent slipping, and at the opposite end, fixed by means of a hinge, a thin rectangular piece of wood, fitted with an adjustable ledge to hold the cassette **(809)**.

For the horizontal position it is usual to raise the upper end of the cassette on a sandbag or block of wood, so that the chin may project over the top edge of the cassette. When the film is flat on the couch the head may be turned to one side, but care should be taken that the thorax does not turn with the head, otherwise the position of the shadows in the resulting radiograph will be misleading; this can be checked by the symmetrical appearance of the clavicles at the sterno-clavicular joints. Comparison should be made of **(807)** with **(808)**.

The tube may be above or below the couch, but few couches, unless specially designed for the purpose, allow of adequate anode-film distance for satisfactory chest work, particularly from below.

When the anode-film distance is restricted from above, a low trolley couch may be used beside the X-ray couch, but this only applies when the tube can be rotated on its stand from above the X-ray couch. When it has been of great importance to secure a film in the horizontal position at an anode-film distance of 72 inches, the writer has placed the patient on the floor beneath the over-couch tube, which has been swung out from over the couch for the purpose.

POSITIONS

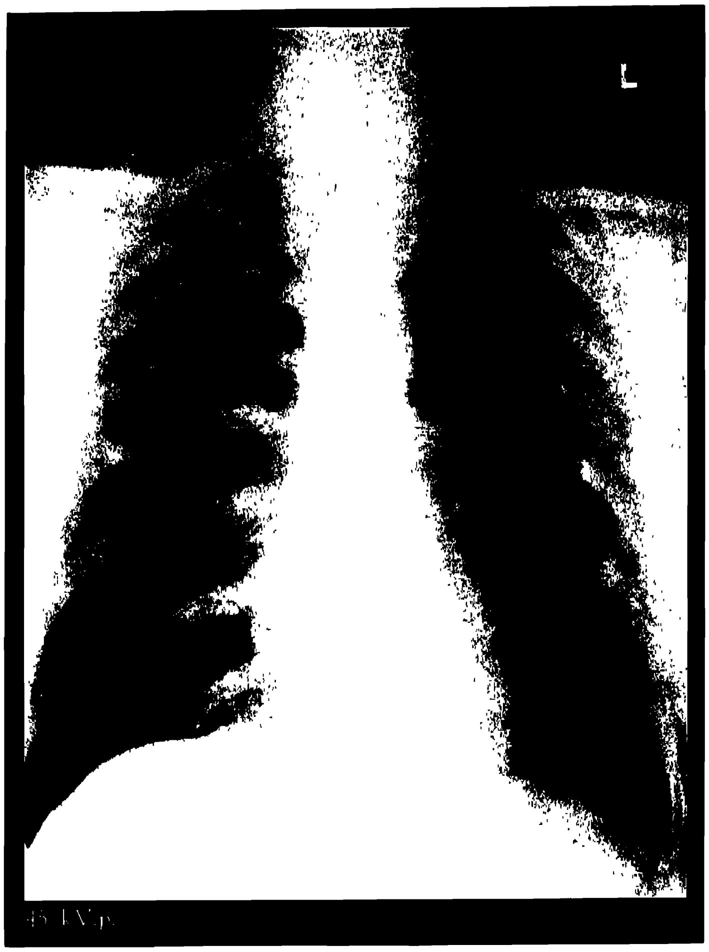
Radiographs may be taken from each aspect of the thorax, postero-anterior, antero-posterior, right and left anterior and posterior oblique, and right and left lateral.

FILM QUALITY

There is, perhaps, a wider variation of opinion as regards the ideal quality and density of chest radiographs than in any other branch of radiography, and the radiographer should be guided entirely by the requirements of the radiologist or medical officer in charge.

Apart from these factors of quality and density it is essential for each film to show the maximum detail, with good definition in the lung tissue and sharply defined outline of heart and diaphragm. The fine demarcation of the lung tissue should be shown from hilum to periphery, and special landmarks which may be seen, although not all in every film, are the subclavian vein over the apex of the left lung, and the inferior vena cava appearing as a triangular shadow within the cardiophrenic angle of the right lung—both of these appearing as low density shadows—and the hair-like line of the fissure between the middle and lower bodies of the right lung.

Generally, films should show the area bounded by the upper borders of the first ribs above and the depressed dome of the diaphragm below, and, laterally, the axillary outline of the bony thorax. The sternal ends of the clavicles should be perfectly centralised, and the shadows of the scapulæ should be excluded from the lung field.



811

812

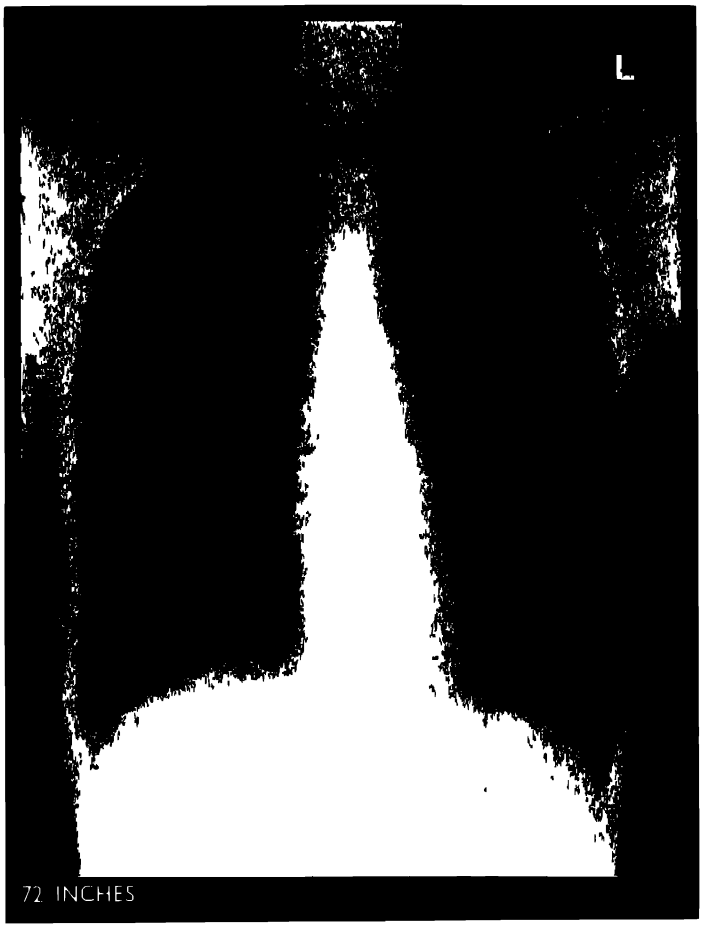
EXPOSURE FACTORS

There is such a wide range of variation between the low kilovoltage chest film, showing great contrast (811), and the high kilovoltage flat type, lacking in contrast (812), that this subject can only be discussed on very broad lines.

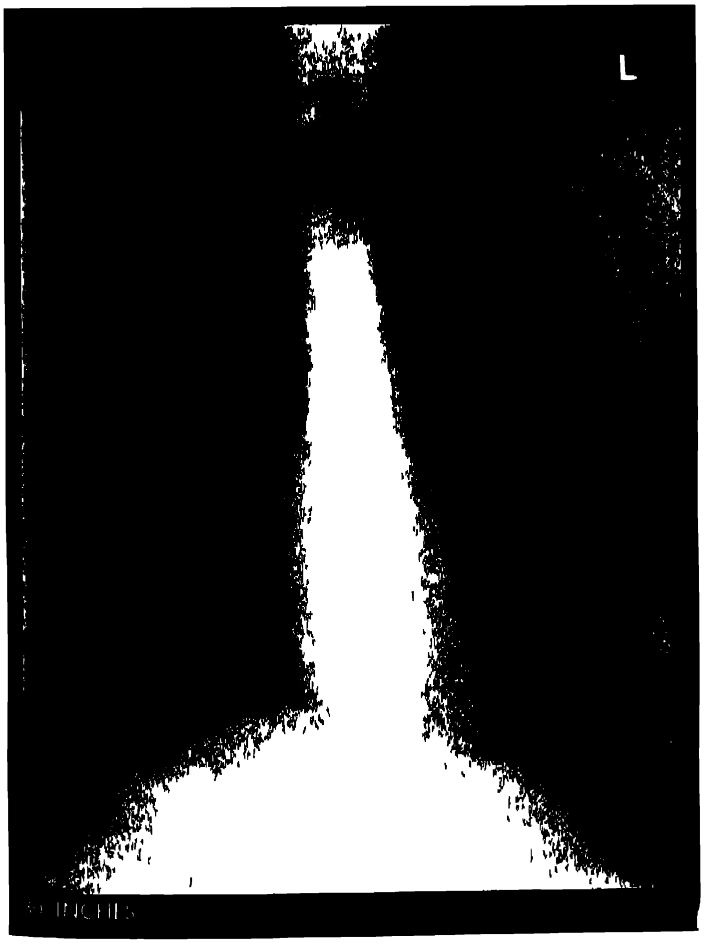
The following brief notes may be of interest to the inexperienced worker. As the elimination of movement is the chief factor in obtaining satisfactory definition, the exposure time should be short, preferably one-twentieth of a second, or less, but certainly not exceeding one-tenth of a second. It is necessary to apply all available milliamperage, and to adjust the kilovoltage to give reasonable density at an anode-film distance of between 60 inches and 72 inches. Should the radiologist require a negative showing greater contrast than that produced, the kilovoltage should be reduced at the expense of the exposure time up to one-tenth of a second, rather than the anode-film distance be reduced below 48 inches. Should the film show too much contrast, the kilovoltage should be increased and the distance also increased if already less than 72 inches, or if the maximum distance has already been applied the exposure time should be reduced.

IMPORTANT

In applying high milliamperage care should be taken to see that the kilovoltage, milliamperage, and exposure time relationship are within the limits indicated on the rating chart of the tube in use.



813



814

ANODE-FILM DISTANCE

When the chest is exposed at an anode-film distance of 72 inches magnification is avoided and the maximum definition is obtained, but unless a high-power unit is available it is not possible to apply the ideal exposure factors at this distance.

On reducing the anode-film distance to 60 inches the latitude in exposure technique is considerably increased, this being of such value that the 60 inch distance is generally preferred, especially as the difference between films taken at 72 inches and 60 inches is almost imperceptible.

Satisfactory lung films can be taken at a distance of 48 inches, but the shorter distance effect becomes noticeable, and for larger subjects a 17 inch by 14 inch film is essential to include the whole of the lung field. On the other hand, suitable exposure technique may be easily adjusted to the unit of smaller output.

In using ward mobile and portable units, with milliamperages ranging from 10 to 30, surprisingly good results can be obtained at a distance of 30 inches to 36 inches when such apparatus is carefully handled. Obviously, the films cannot be of the same standard as those obtained with the high-power unit, but with care they will be found to be of great value in the case of the very sick patient who cannot be moved from the private bedroom or hospital ward to the X-ray department. **(813, 814)**

INTENSIFYING SCREENS

Provided the milliamperage output is sufficiently high to apply a short exposure, the fine-grain, medium-speed screens are preferable, but if only a low-power unit is available the use of fast screens will be found an advantage.

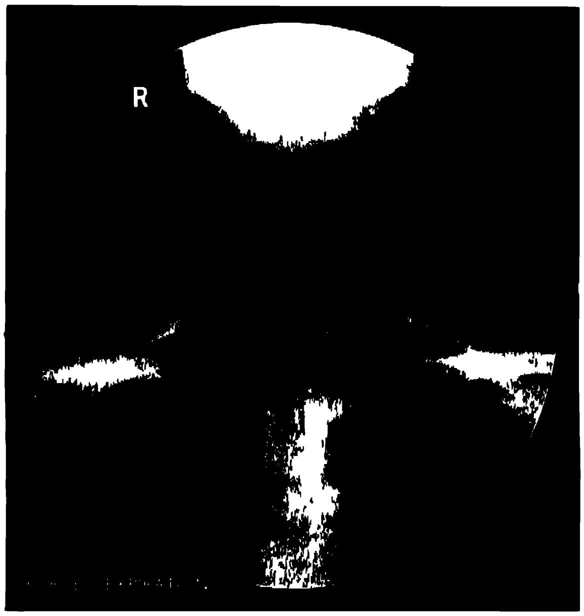
LOCALISING CONES

For teleradiography a localising cone is essential, for, apart from improving lung definition, it limits the area of radiation, which is a most desirable feature, particularly in a small room where it is liable to reach others than the patient, in either primary or secondary form, and especially where it is necessary for the operator to work near to the patient. When the film is taken in the screening stand the rectangular diaphragm limits the beam of radiation to the fluorescent screen, which is protected by lead glass, thus affording, in conjunction with the lead rubber apron flaps, adequate protection to the operator when proper care is exercised.

IDENTIFICATION

Identification of lung films is most important, not only from patient to patient but as to right and left sides. In identifying right and left without an indicating marker,

815



816

817

IDENTIFICATION *(continued)*

there is always the rare possibility of transposition of the organs, so that the level of the diaphragm, or gas shadow indicating the fundus of the stomach, may be misleading in the radiographs unless they are properly marked or an abnormality disclosed by screen examination has been duly recorded. There are, also, abnormal lung conditions where displacement of the heart and a general opacity of the lung also render difficult, from the anatomical appearance of the organs alone, satisfactory identification of right and left sides.

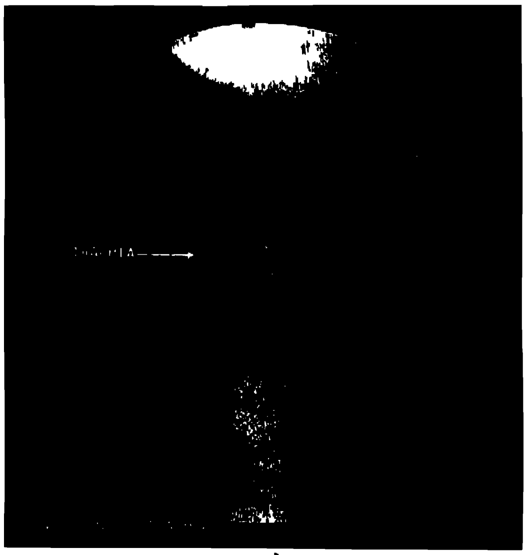
The exposure factors quoted in the text apply to an adult subject of 125 pounds weight and having on inspiration, at the level of the axilla, a postero-anterior thickness of 9 inches and a lateral thickness of 10½ inches. Additional exposure factors given on page 315 apply also to larger (185 pounds) and smaller (107 pounds) subjects. Furthermore, a full table of exposures according to chest thickness measurement is given on pages 499 to 501.

Trachea

The identification of the position of the trachea is dependent upon its being filled with air, this hollow cavity being visible from the antero-posterior aspect as a dark shadow superimposed upon the spine under normal conditions, and, when a pathological displacement occurs, overshadowing the adjacent soft structures of neck and thorax. Such deviation may be due to the pressure of a goitre or other new growth **(818)**.

Radiographs of the trachea are usually taken following a visual screen examination, so that information regarding its displacement from the mid-line is available before the films are exposed.

The full extent of the trachea is well demonstrated in films exposed to show the cervico-dorsal vertebræ from



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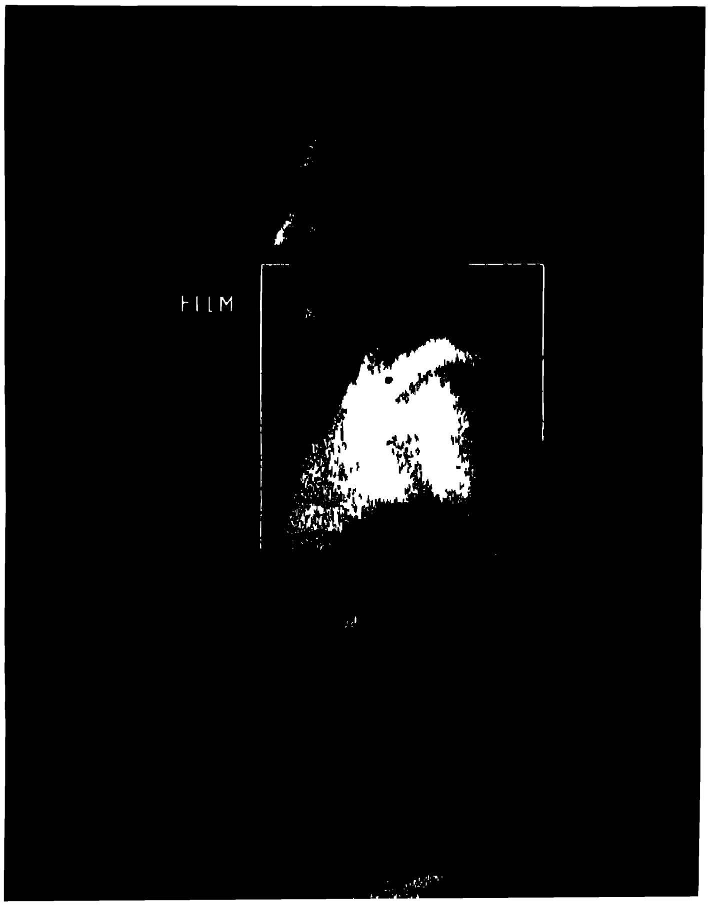
819

820



Respiratory System: Trachea

the antero-posterior aspect, and although it is also shown in all lung films the exposure for the lungs is inadequate to show the trachea, an increase of 10 kilovolts being necessary to obtain the requisite density. For the trachea the exposure should be made, in both postero-anterior and lateral views, on forced expiration, with the mouth closed so that the mouth and upper air passages are also distended with air. This is shown in (816) and (820) as compared with (815) and (819) taken on normal expiration.

POSTERO-ANTERIOR

The patient is placed with the anterior aspect of the neck and the upper thorax toward the film.

CENTRE over the second dorsal vertebra.

(815, 816, 817, 818)

EXPOSURE FACTORS						
	mA. Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	23	14	36″	Ilford	Tungstate	—
70	60	36	36″	Ilford	Tungstate	Potter-Bucky

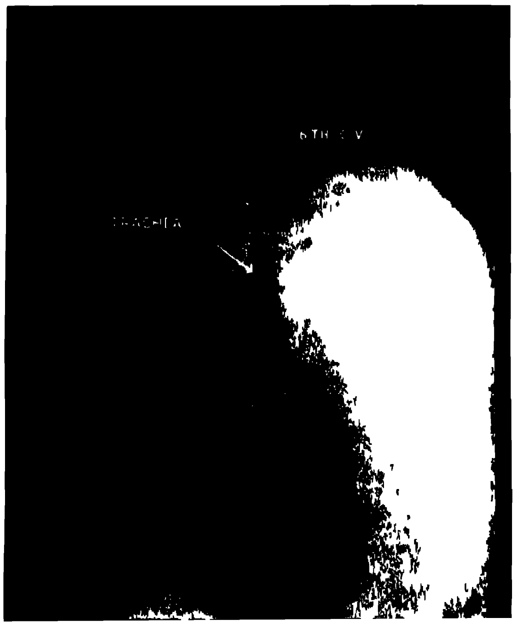
NOTE—When use is made of the Potter-Bucky diaphragm the antero-posterior position is applied (817).

LATERAL

The film is placed on the lateral plane of the upper arm and cervical region. The arms are pressed backward and the chin raised.

CENTRE over the mid-clavicular region (821, 821a).

For the lateral view (821a) an anode-film distance of 60 inches is necessary with an increase of 30 kilovolts on the exposure factors quoted for the antero-posterior view.



821a

Lungs

POSTERO-ANTERIOR

The subject is placed facing the cassette, with shoulders level and the extended chin resting on top of the cassette or hollowed film support. The shoulders are rotated forward and downward, in contact with the cassette. This is achieved by (*a*) allowing the arms to encircle the cassette **(822)**, (*b*) placing the dorsal aspect of the hands behind and below the hips **(823)**, or (*c*) rotating the arms forward and outward **(824)**. Any one of these methods will effectively project the scapulæ laterally away from the lung fields. The shoulders should not be raised, or the apices will be obscured by the clavicles.

In the horizontal position the upper end of the cassette is raised to allow the chin to project over the top edge.

In applying the shorter anode-film distance in the horizontal position the tube is angled 10 degrees toward the feet **(828)**. This serves to project the shadow of the diaphragm to a lower level, and thus allows a larger area of lung field to be included.

CENTRE to the sternal angle, through the fourth dorsal vertebra. Films are taken on normal full inspiration.

(822, 823, 824, 826, 828)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Patient Size
53	25	20	60″	Ilford	Tungstate	9″
48	25	20	60″	Ilford	Fluorazure	9″

Cone to size of film, 15×12 in. or 17×14 in.

In subjects where the apices are not clearly demonstrated an additional small film should be taken, with the tube centred over the apices and angled 20 degrees toward the feet.

ANTERO-POSTERIOR

The patient is placed facing the tube, with the shoulders level and the chin raised and forward. The shoulders are brought downward and forward, with the backs of the hands below the hips and the elbows well forward.

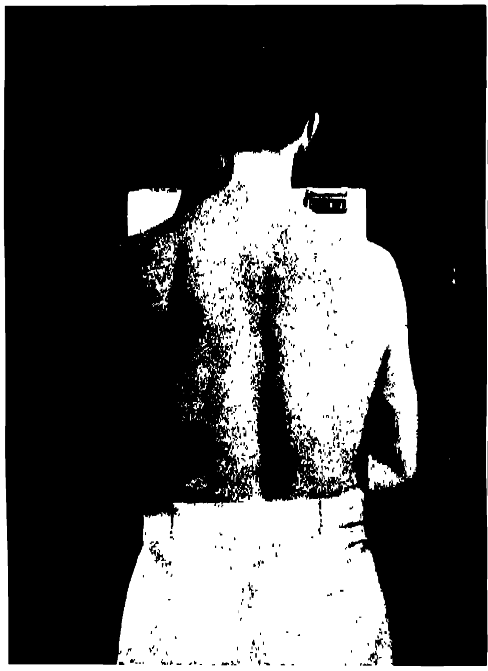
CENTRE to the sternal angle, and expose on inspiration as previously.

(825, 825a, 827, 827a)

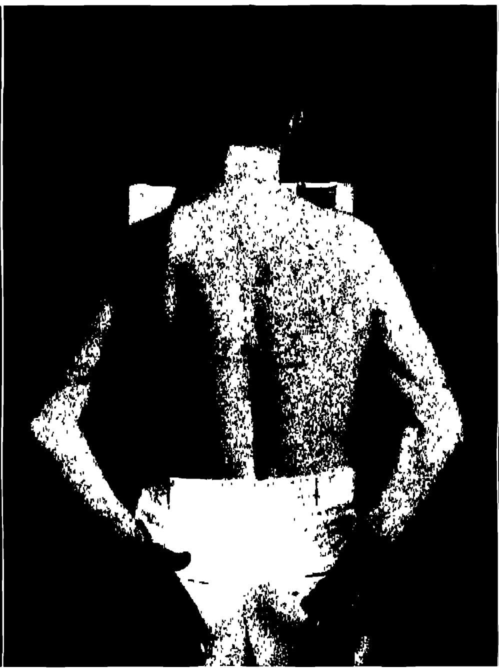
NOTE—The kilovoltage should be increased by 4 as compared with the postero-anterior view.

Views **(826, 827)** should be compared, as should the two views shown in **(827a)**, when it will be seen that in the antero-posterior views the apices of the lungs are shown well clear of the shadows of the clavicles. In many instances abnormal shadows, obscured in the postero-anterior view, may be well demonstrated in the antero-posterior view, thus enabling a decisive radiological diagnosis to be given. These two views might well be considered in effect as being similar to the two views which are regarded as essential for the radiological examination of most other regions of the body.

NOTE—It is usually necessary to take the really sick patient in the antero-posterior position, either semi-recumbent or wholly recumbent, difficulty being frequently experienced in projecting the scapulæ beyond the lung field. **(829)**



822



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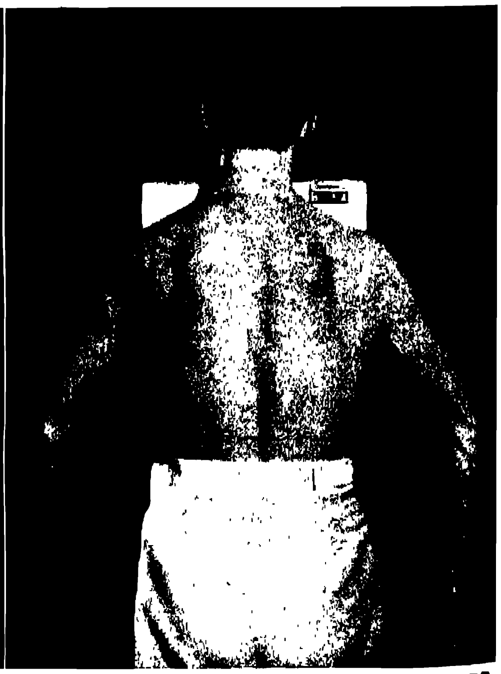
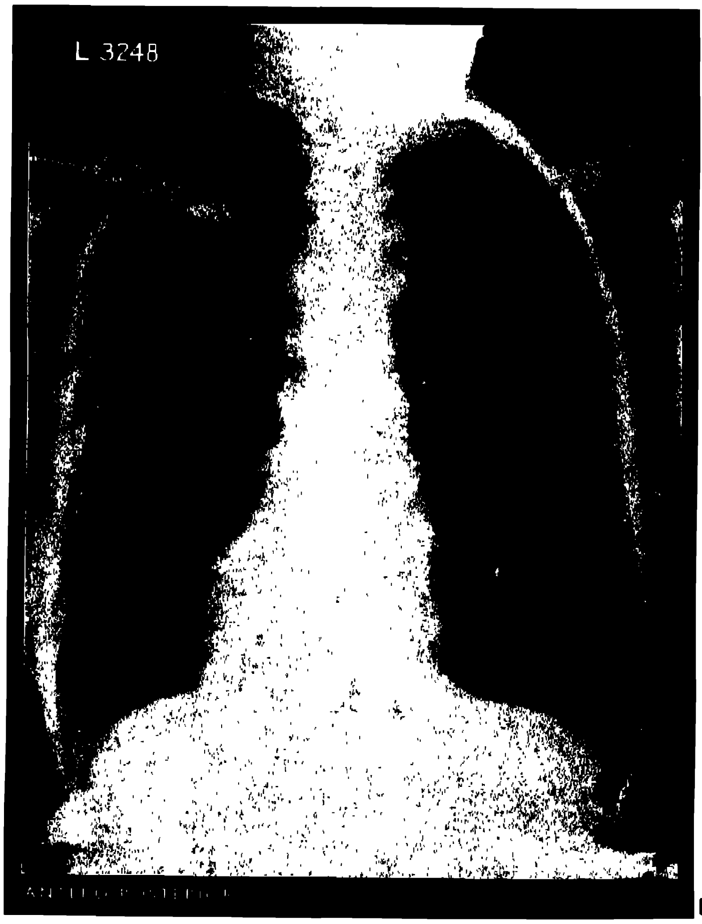


824


825


825a

826



827

827a

828

829

ANTERO-POSTERIOR (*continued*)
EXPOSURE TABLES

Further data on exposure technique for the lungs is given in the tables shown on pages 499 to 501, where the measured thickness of the subject, ranging from $6\frac{1}{2}$ to $14\frac{1}{2}$ inches, is the basis for exposure conditions for the postero-anterior view. A second table shows the requirements for other views—antero-posterior, right and left anterior oblique, lateral, lordotic, and in special conditions where the use of the radiographic grid is necessary.

These tables are satisfactory so long as processing is standardised. The use of a developer replenisher is recommended.

HORIZONTAL POSITIONING FOR FLUID LEVELS

When the subject is restricted to the horizontal position, lung films are taken and fluid levels shown by rotating the patient on to the sound side. The film is then placed to the anterior or posterior aspect and the beam projected from the horizontal plane (**832, 832a**). To show a fluid level when the patient cannot move into the lateral position, the film is placed vertically against the affected side and the beam projected from the opposite side (**833, 833a**). By either of these methods the whole of the lung field may be disclosed, medial and lateral, and anterior and posterior, respectively, by reversing the position, although with the patient recumbent and in the prone position right and left lungs coincide.

Films taken of the same patient in the erect position are shown in (**830, 831**). In addition, the upper chest may be raised or lowered—using a tilting table when available—to allow the fluid contents of a cavity to fall to the lowest level in order to disclose the unfilled portion of the cavity. This applies also when, as in the case of empyema, a small quantity of iodised oil has been injected through an external sinus for the purpose of outlining the cavity.

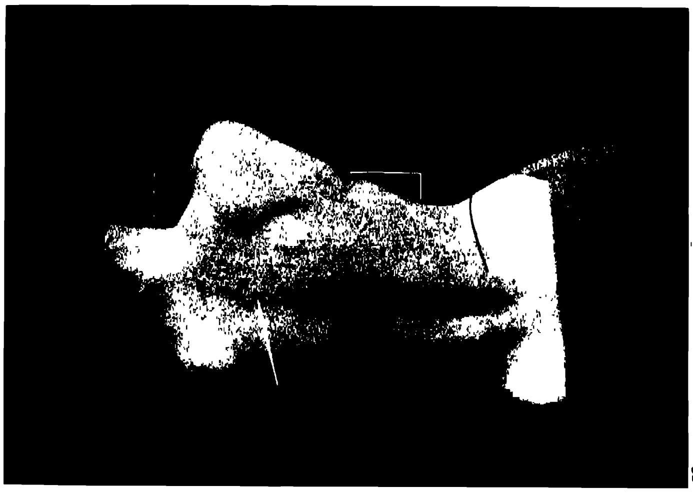
In a case of *pneumothorax* (**830**) it is important that the complete series of films, from the initial film taken at, or before, the commencement of treatment to the final film taken on its cessation—particularly these two—should be as nearly as possible of similar quality in every respect.

POSTERO-ANTERIOR ERECT

830

LATERAL ERECT

831



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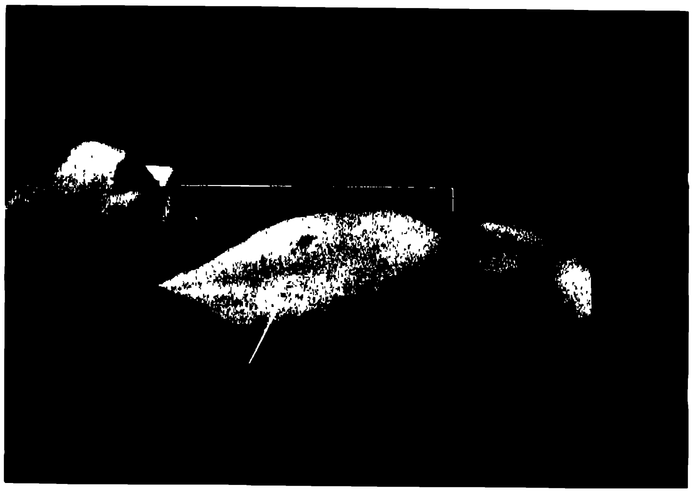


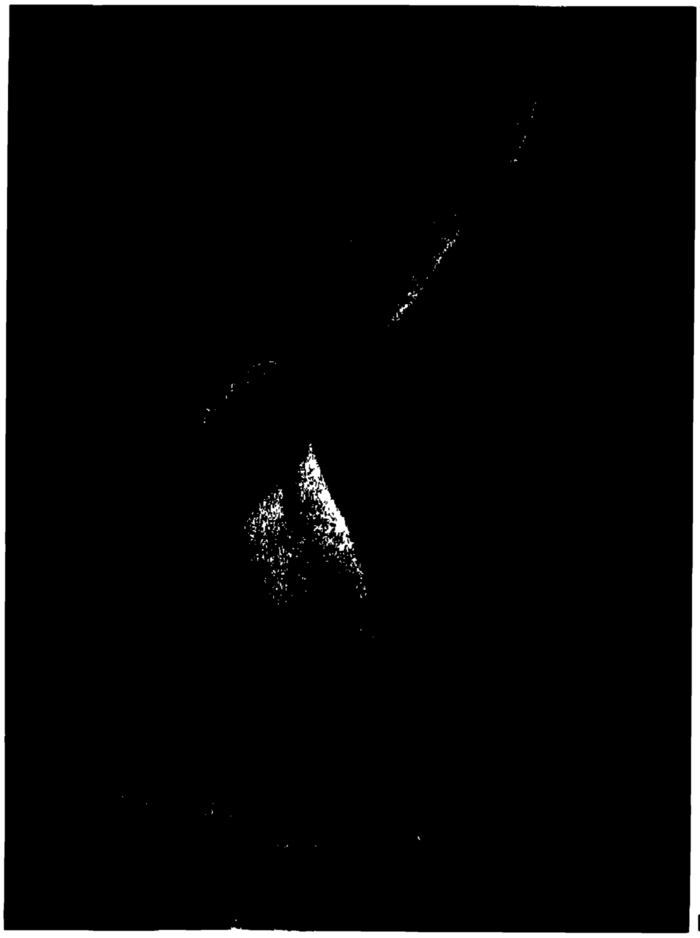
833

POSTERO-ANTERIOR PATIENT LATERAL HORIZONTAL

832a

LATERAL PATIENT SUPINE HORIZONTAL

833a



834

Respiratory System: Lungs

LATERAL GENERAL

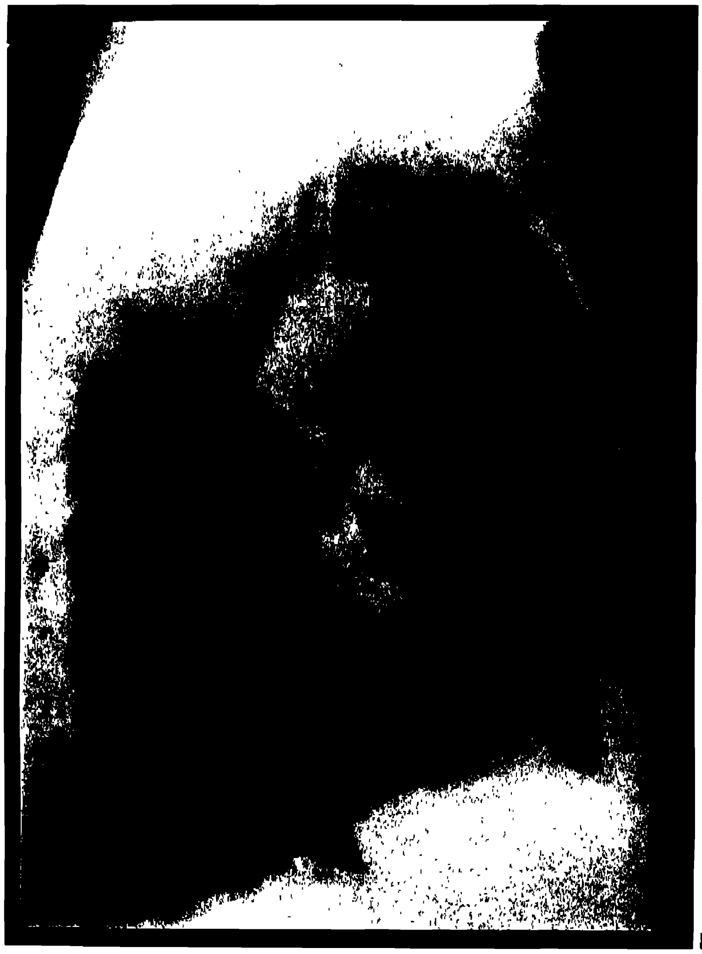
The patient should be placed with the lateral aspect of the affected side in contact with the film, and the arms folded or extended over the head to rest on a bar support.

CENTRE through the axilla (834, 835).

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Patient Size
75	25	20	60″	Ilford	Tungstate	10½″
70	25	20	60″	Ilford	Fluorazure	10½″

NOTE—The additional thickness from this aspect necessitates an increase of 20 kilovolts as compared with the kilovoltage required for the postero-anterior view. Alternatively, the exposure time may be doubled and the kilovoltage increased by 10 kilovolts only, to avoid producing a film lacking in contrast due to over-penetration; or, to avoid movement during increased exposure time, the anode-film distance may be reduced.

It should be noted that the condition disclosed in the postero-anterior view serves to indicate when it is necessary to take the additional, lateral view (835, 836).



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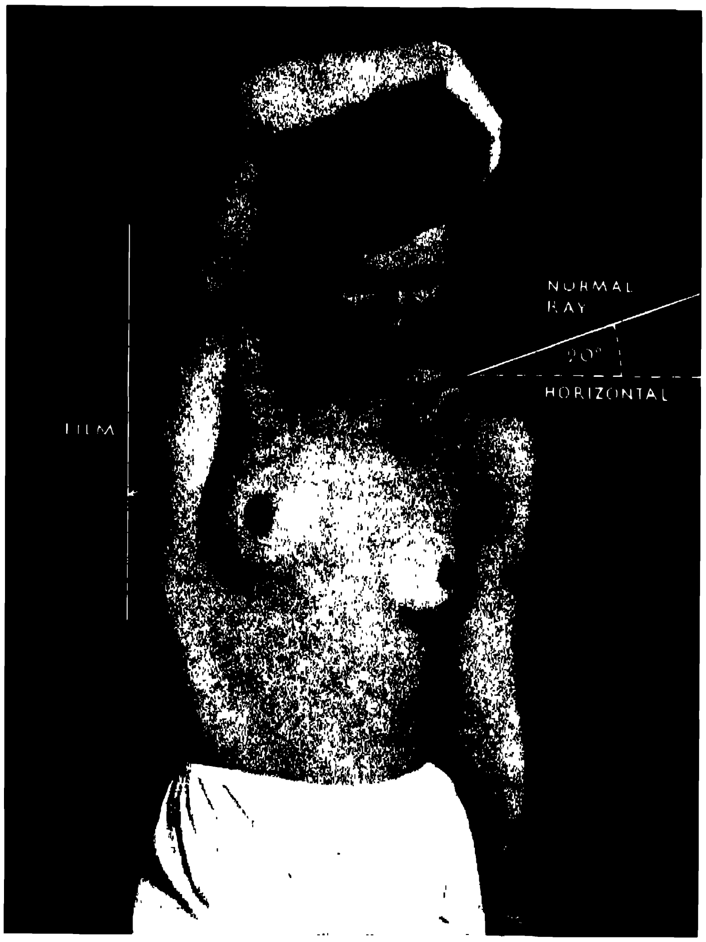
836



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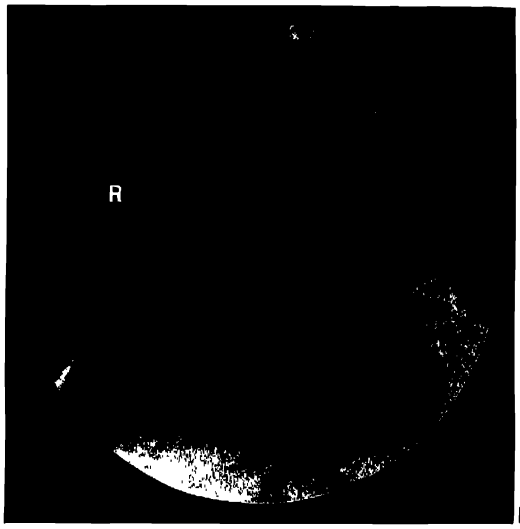


837a

838

Respiratory System: Lungs

LATERAL APICES

The patient is placed in the lateral position, with the axilla of the affected side toward the film, and the arm folded over the head, the opposite arm resting beside the trunk, which is allowed to bend laterally from the waist away from the film.

CENTRE above the shoulder of the side nearest the tube, with the tube angled 20 degrees toward the feet.

(837, 837a, 838)

EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
87	15	12	48″	Ilford	Tungstate	—

GENERAL EXPOSURE FACTORS

Three sets of exposure factors are given, one each for small, medium, and large subjects, using Blue Label Developer and Ilford Tungstate Screens.

Patient:—Weight 107 lbs.				
kVp.	mA. Secs.	Distance	Thickness	Position
53	20	66″	7¾″	P.A.
75	20	66″	9″	Lateral
58	15	36″	—	Oblique

Patient:—Weight 124 lbs.				
kVp.	mA. Secs.	Distance	Thickness	Position
53	20	60″	8¾″	P.A.
75	20	60″	10½″	Lateral
60	15	36″	—	Oblique

Patient:—Weight 185 lbs.				
kVp.	mA. Secs.	Distance	Thickness	Position
58	25	60″	10¾″	P.A.
80	25	60″	12½″	Lateral
65	20	36″	—	Oblique

839

Respiratory System: Lungs

OBLIQUE

The right and left anterior oblique views are taken to show the mediastinum. It is essential to screen for these positions as there is considerable variation in the degree of rotation required from subject to subject and from right to left. Were other exposure factors maintained it would be necessary to increase the kilovoltage required for the postero-anterior view by 15 kilovolts, but as a 36 inch anode-film distance is necessary in order to obtain adequate projection separation of heart and spine to disclose the mediastinum, an increase of only 5 kilovolts is required.

LEFT ANTERIOR OBLIQUE

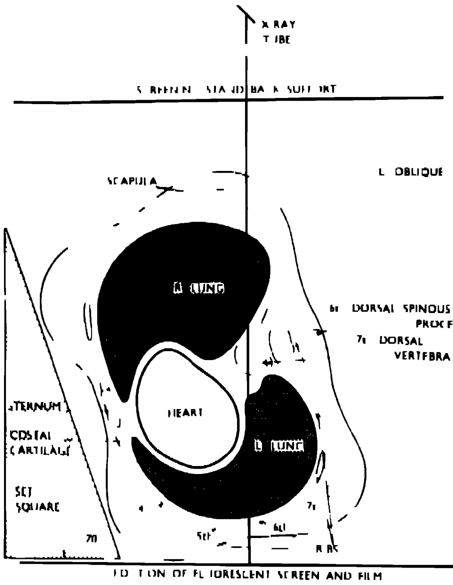
The left shoulder is placed in contact with the film, and the right shoulder rotated away until the thorax is at an angle of approximately 70 degrees to the film. The right arm is raised and supported in front of the subject and the left arm is slightly posterior, or both arms are raised and folded as shown in the illustration. The exact position for each patient is obtained by screen examination.

CENTRE over the right scapula, at the level of the fifth dorsal vertebra.

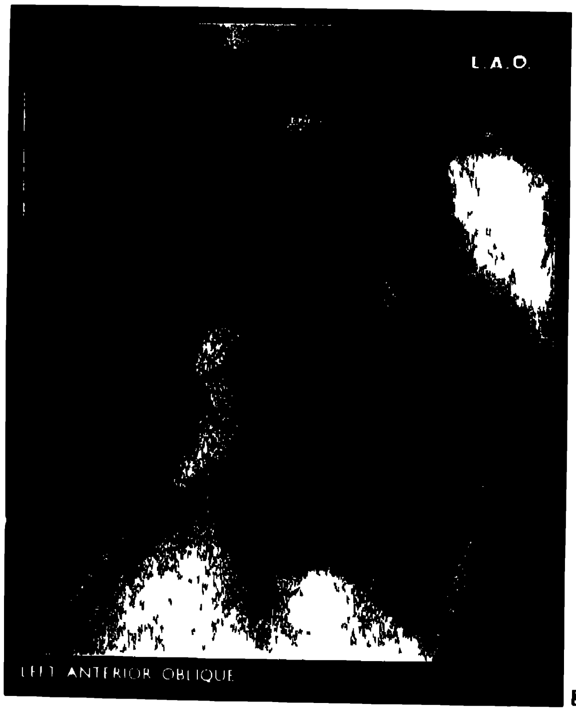
(839, 840, 841, 842)

It should be noted that greater rotation is necessary for the left oblique view than is required for the right.

The cross-sectional diagrams **(840)** and **(844)** show the tube-film-subject relationship.



840



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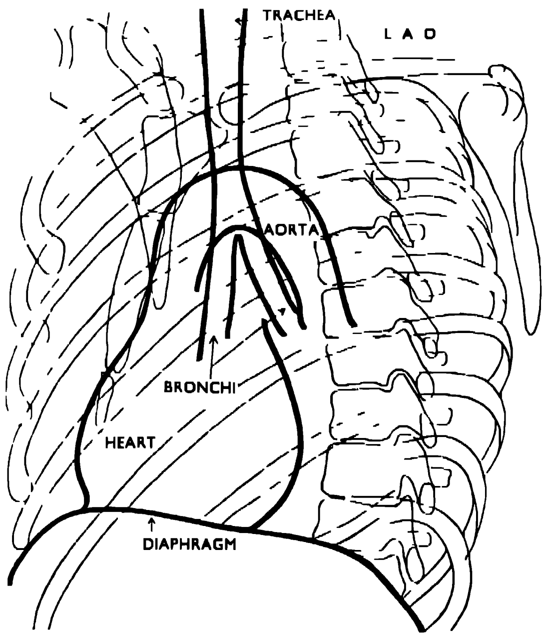

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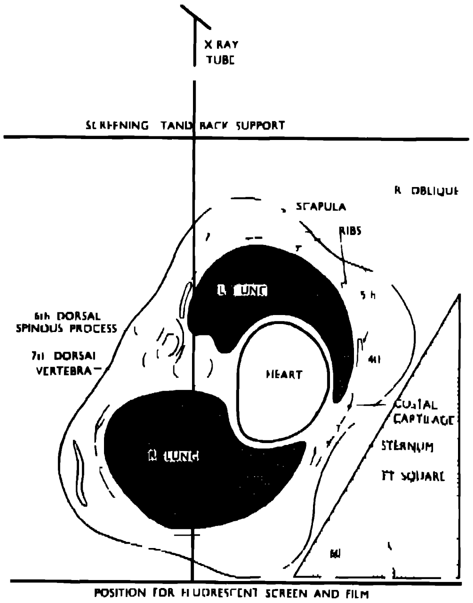
843



844

845

Respiratory System: Lungs

RIGHT ANTERIOR OBLIQUE

The right shoulder is placed in contact with the screen, and the left shoulder is rotated away from the film until the thorax is at an angle of approximately 60 degrees to the film. The arms are moved away from the trunk to avoid obscuring the lungs. In screening for this position the patient is rotated until a clear space is shown between the posterior border of the heart and the spine.

CENTRE over the left scapula, at the level of the fifth dorsal vertebra.

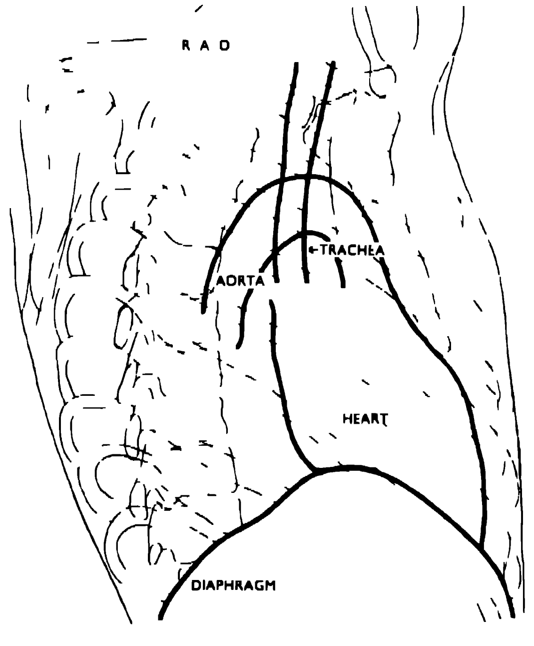
(843, 844, 845, 846)

EXPOSURE FACTORS					
	mA Secs				
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford
60	18	15	36″	Ilford	Tungstate
55	18	15	36″	Ilford	Fluorazure

Tracing diagrams (842, 846) are included for the purpose of identification of the structures appearing in the radiographs.

MODIFIED OBLIQUE

In addition to the general oblique view a modified position may be used to show the apices, the patient being turned through approximately 20 degrees from the postero-anterior position for right and left sides in turn.



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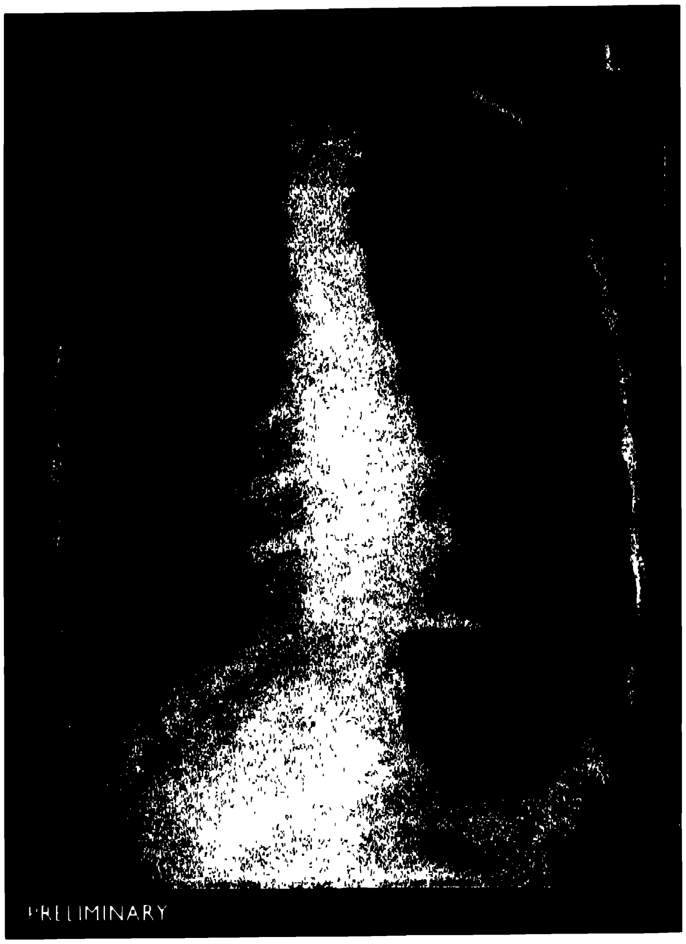
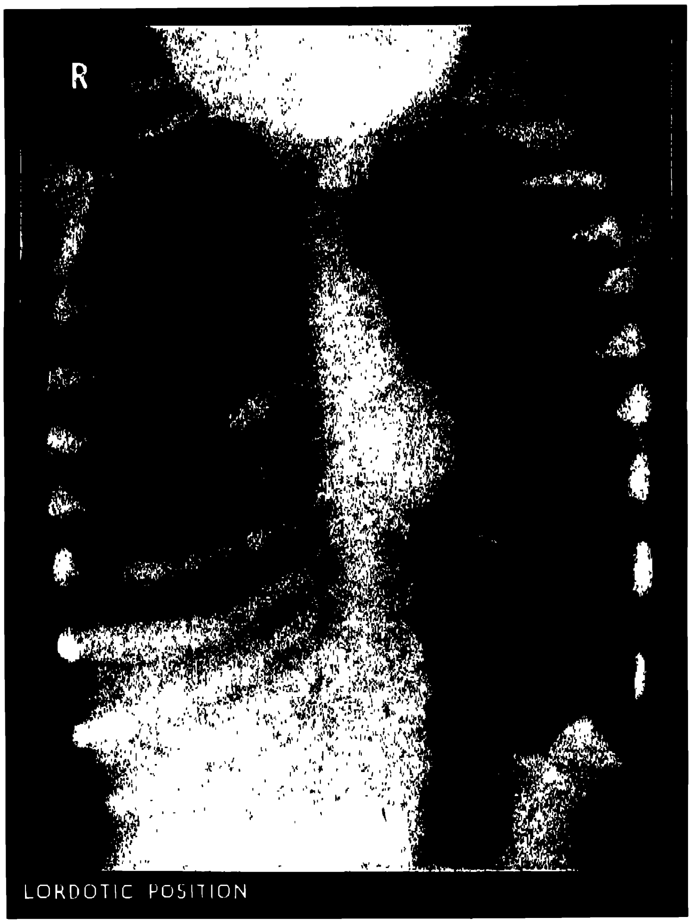


847

LORDOTIC POSITION

When case note or film evidence of a mediastinal pleurisy is shown, additional exposures should be made with the patient in what is known as the lordotic position. For this view dorsiflexion, that is, bending backward from the waist, is applied with the patient facing the film, and it is helpful if the hands can grasp two vertical supports as shown in **(849)**. The patient, in the erect position, is asked to practise gently leaning back, away from the support, and when this movement is repeated during visual screen examination, the ideal position can be determined for demonstrating the sharp wedge-shaped fluid concentration shadow in **(848)**. The degree of dorsiflexion required will vary from subject to subject and can only be determined by screen examination.

Illustration **(849)** shows the relative positions of patient and film cassette. It should be noted that the radiographs show a much reduced difference between the levels of the anterior and posterior rib endings. Comparison should be made with films taken of the same patient in the normal postero-anterior and lordotic positions **(847, 848)**.



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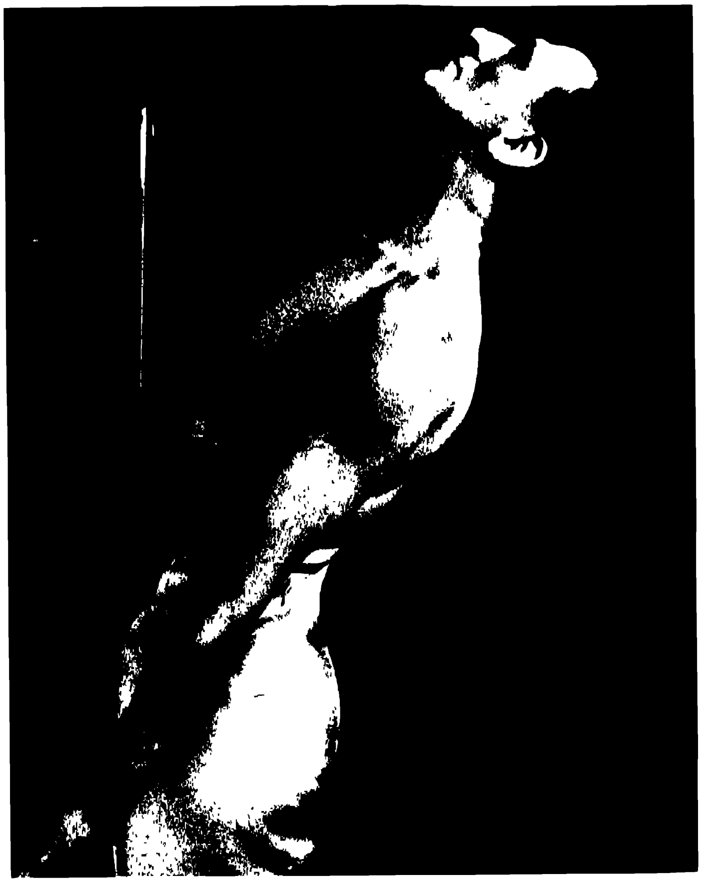
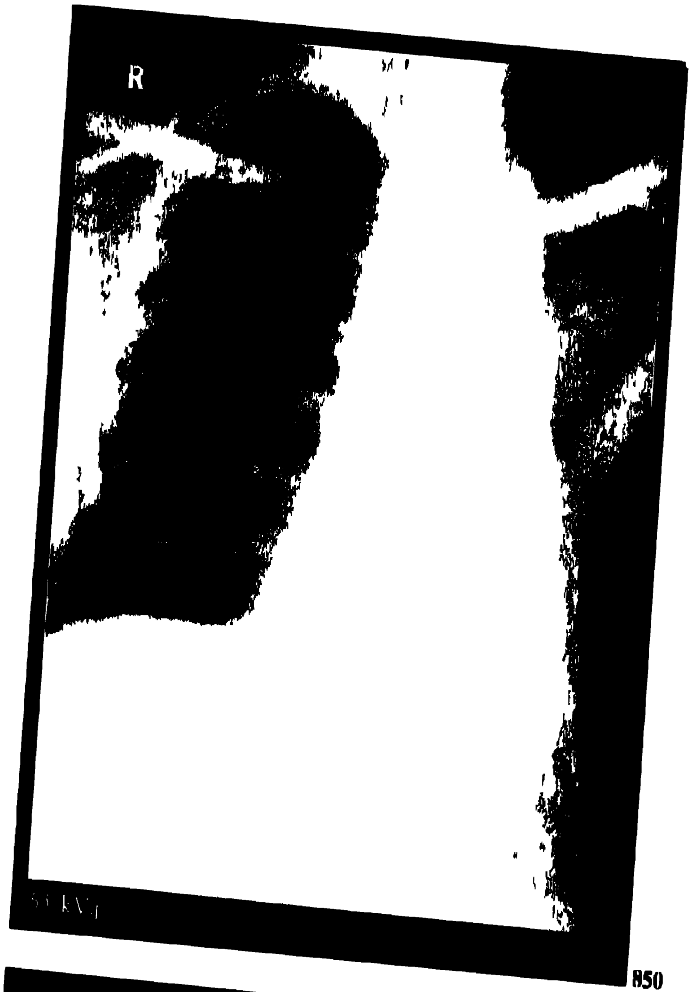


849



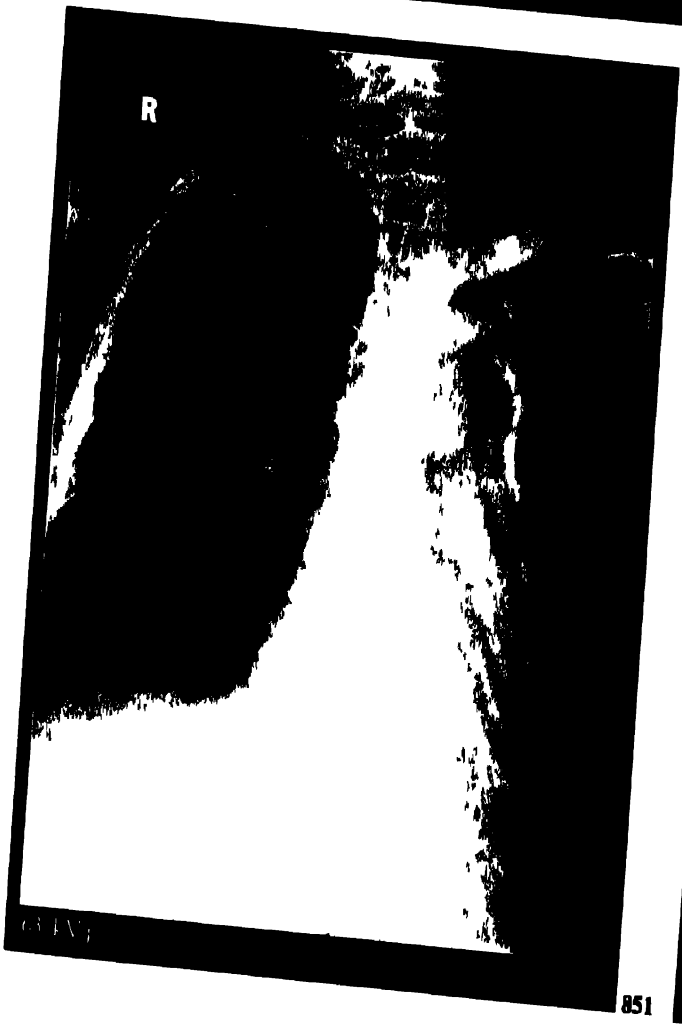
850

Respiratory System: Lungs

For the lordotic position an additional 10 kilovolts is required as compared with the exposure factors quoted for the postero-anterior view. However, as the distance factor is unimportant for this view, it may be more convenient to expose the films from the distance used for the screen examination, in which case the exposure conditions should be adjusted accordingly.

CONDITIONS REQUIRING VARIATION IN EXPOSURE FACTORS

An opacity of the lung requires increased penetration of from 15 kilovolts to 20 kilovolts, the lung detail of the opposite side then being obscured by over-penetration. To avoid unequal density a 2 millimetre to 4 millimetre aluminium filter may be placed over the cassette to cover the normal lung field so that in the resulting film both lungs may be equally well shown. The necessary evidence of the use of the filter is shown in the mid-line, particularly in the cervico-dorsal region. In these cases the Potter-Bucky diaphragm or stationary grid may sometimes be used to advantage. **(850, 851, 852)**



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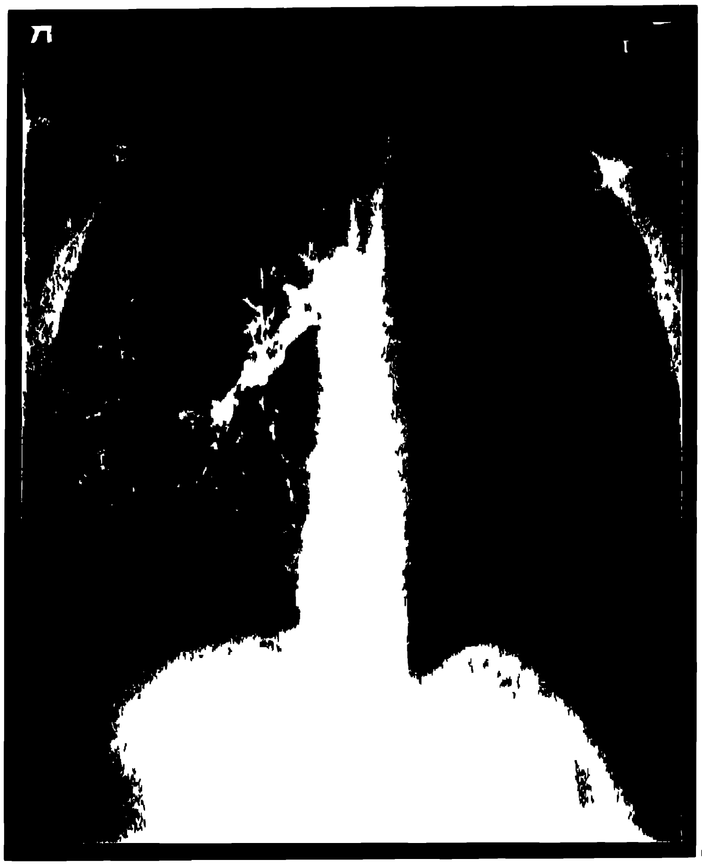
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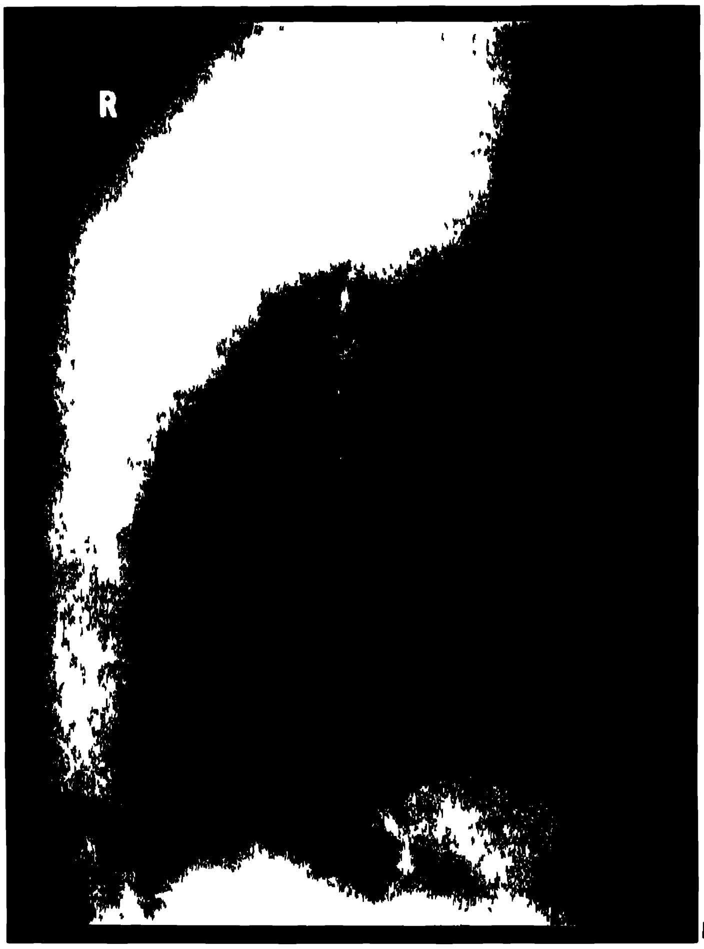
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Bronchography

The purpose of this examination is to investigate the lungs for dilatation of the bronchi—known as bronchiectasis—or to demonstrate pulmonary cavitation. A preparation of iodised oil is used as an opaque medium to outline the bronchial tree. It is supplied under various trade names, sterilised and ready for use.

The iodised oil can be introduced into the trachea by a hollow needle inserted through the cricothyroid membrane, or by a canula inserted into the larynx through the mouth, or by a nasal catheter.

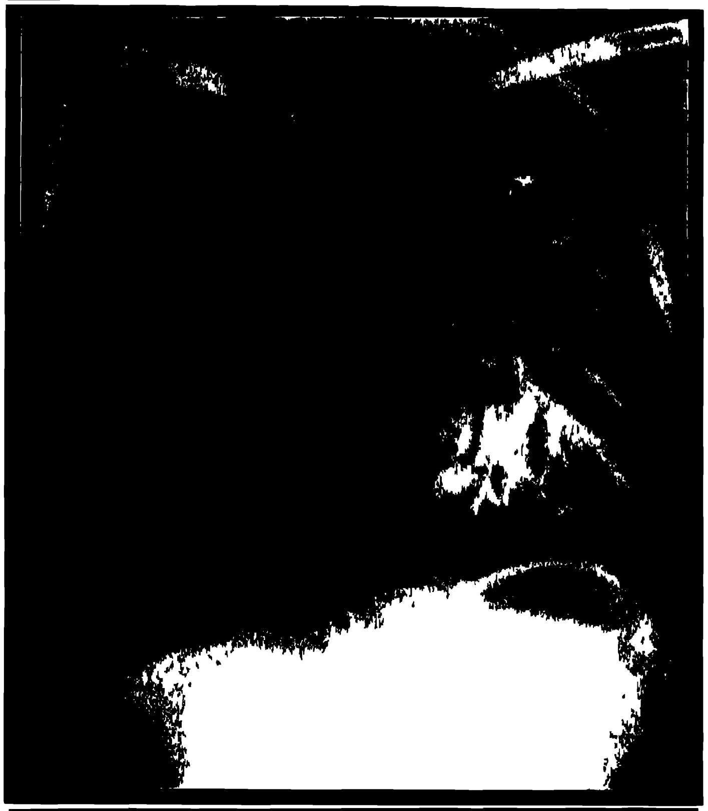
The actual method of injection is of no concern here, except as far as the nice adjustment of the patient is concerned before, during, and after the injection.

Whether the injection is given with the patient in the sitting or horizontal position, it is important to place a firm sandbag in the nape of the neck so that the patient rests with the neck slightly extended—this is especially important at the commencement of the injection. During the injection the patient is rotated from side to side and backward or forward, according to the area of lung required. To show the lung apices the lower end of the table is raised to enable the iodised oil to permeate the upper bronchi. To show the anterior upper lung area, and in the absence of a tilting table, the prone position is used, with the lower trunk raised so that the iodised oil flows to the then lowest level of the apices. Should only one apex be required the arm and shoulder of the affected side are allowed to hang over the edge of the couch **(855)**. Preliminary films are essential and should always be available at the time of the injection.

When the direction and also the extent of the ramifications of the bronchi are appreciated, **(853, 854)**, it will be realised that in order adequately to demonstrate the *whole* of the bronchial tree, examination in the several positions is essential.

Before the injection everything should be prepared in readiness for taking the first radiographs. The whole procedure should be well organised in order to avoid an undue lapse of time between the completion of the injection and the making of the series of exposures. The patient's confidence should be gained, so that he or she may collaborate to avoid coughing until such time as the requisite number of films has been taken.

855



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857

Respiratory System: Lungs—Children

Films may be taken in the postero-anterior (853), lateral (854), and oblique positions, both horizontal and erect.

Greater penetration is required than for ordinary lung radiographs, especially for the bases and over the heart shadow, the increase required being from 10 kilovolts to 15 kilovolts (856, 857).

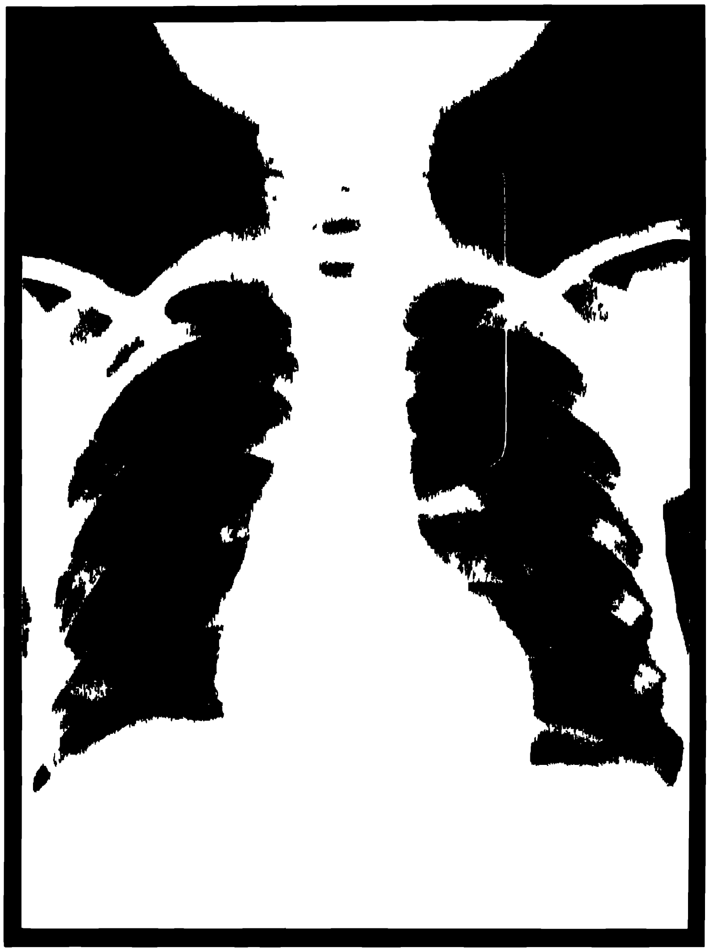
In certain conditions, as where a pathological condition gives rise to an area of great opacity, a radiographic grid may sometimes be used to advantage, but a short exposure time is imperative.

A brief screen examination is usually made prior to taking the films. On the completion of the radiographic exposures the patient is encouraged to expectorate the iodised oil. Although a certain amount of the preparation is usually swallowed, the patient should be advised to avoid this as much as possible, as absorption of the iodine may, in certain rare cases of intolerance, give rise to iodism.

CHILDREN

Young children are more easily taken in the supine position. All should be prepared in readiness for the exposure, using a short exposure technique, the tube being centred one third of the film's length from its upper edge, so that when the child is placed in position the exposure may be made immediately. Some ingenuity is required, not only in obtaining the correct position, but in making the exposure on inspiration. For the latter it is frequently necessary to close the child's mouth and to compress its nose immediately before the exposure is made.

In taking films of young children the difference in the kilovoltage required on inspiration and expiration should be appreciated, also the relatively high kilovoltage required for children under 5 years of age as compared with that necessary for children of 10 years or more.



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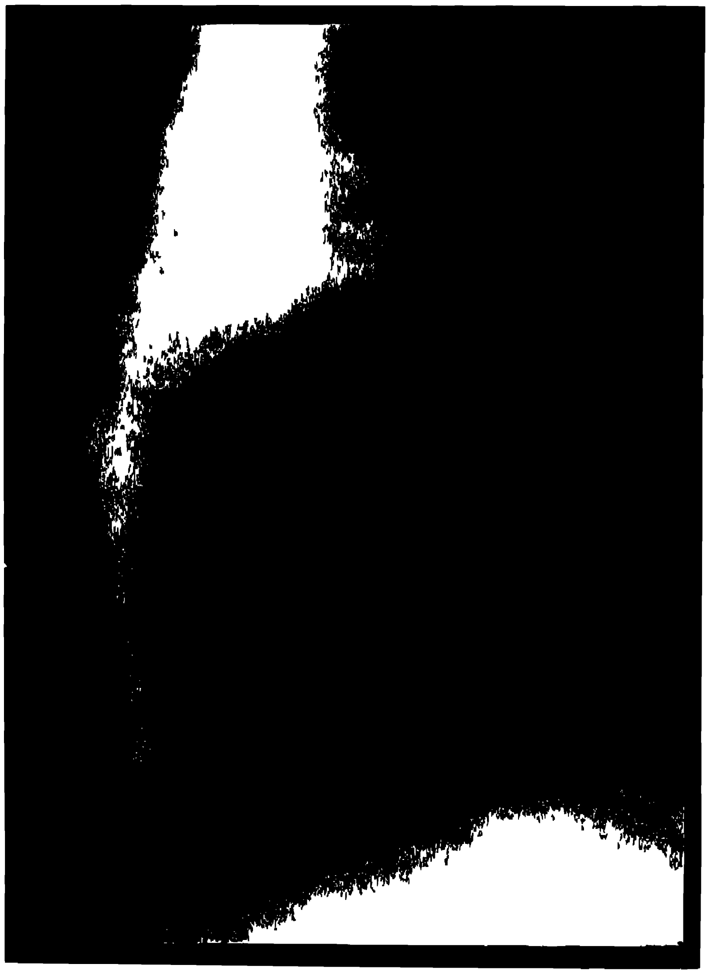

859

THYMUS

Occasional requests are received for the X-ray examination for enlargement of the thymus gland in young children, and as the same exposure technique is applied as for the lungs, it is included in this section.

The thymus gland consists of two lobes in close contact in the median plane, partly in the neck and partly in the thorax behind the sternum. It extends from the level of the seventh cervical vertebra to the level of the sternal angle or fourth dorsal vertebra. The thymus gland increases in size during childhood until puberty, when it gradually dwindles and changes. The gland shadow is clearly shown when the child is crying, and this, actually, is the best time at which to make the exposure. It is necessary to take postero-anterior and lateral views to include the neck and thorax.

The postero-anterior position is preferable, but may sometimes be impossible to apply, especially when the child is frightened. In these circumstances the antero-posterior view is an acceptable substitute. It is important throughout to see that the child's head is in alignment with the body, as slight rotation of the head on the trunk gives an image deceptive as to the size of the thymus. Two films show the regions to be included for this condition. The exposure factors apply to a child aged 6 years.

(858, 859)

POSTERO-ANTERIOR

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
50	4	2	42″	Ilford	Tungstate	—

LATERAL

EXPOSURE FACTORS						
	mA. Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
55	8	5	42″	Ilford	Tungstate	

Size of film, 12 × 10 in.

SECTION 21

Tomography

TOMOGRAPHY

The method of showing individual longitudinal planes in the body has been known under various names which have been applied chiefly to define the type of apparatus employed. Of these names *Tomography* has been generally adopted as indicating the examination of a selected layer, or number of layers, in a specified region of the body. The term is, therefore, applied to this section on "differential" or "layer" radiography.

The obscuring of unwanted shadows by diffusion has long been practised to some considerable extent, examples being the demonstration of superficial structures, such as the temporo-mandibular joints and sternum, by reducing the anode-film distance to diffuse near-*tube* structures while showing clearly those near the *film;* and the encouraging of gentle respiration during exposure to produce diffusion of the ribs over the sternum as seen from the oblique aspect or over the dorsal spine from the lateral aspect. In tomography, however, diffusion of all structures save the particular plane under examination is brought about by linked movement of tube, grid and film about the plane to be shown, and examination by this method, therefore, is not confined to any one layer or to any particular region of the body, although it is of greater value in some regions than others.

The apparatus consists, briefly, of a pivoted metal bar joining the tube and Potter-Bucky diaphragm, by means of which they are given opposed movement about an adjustable axis. The tube moves in an arc, or in a plane parallel with the film, the X-ray beam being restricted to a particular area by the attachment of a localising cone. The position of the centre of movement is adjusted to the depth of the layer required, there being a graduated depth scale for the purpose. To ensure that this is the depth of the layer depicted on the film, however, it is essential for the driving pin to be placed at the *film* level of the Potter-Bucky diaphragm.

The extent of movement of the tube is variable: a total displacement of 20 inches is generally suitable, and the distance adopted is adhered to throughout the examination.

Centring is adjusted with the tube in the "normal" position. The use of the localising cone is essential in order to confine the exposure to the immediate region concerned throughout the tube movement.

It will be appreciated that although degree of definition is governed principally by the ratio between the anode-layer and layer-film distance, the angular distance of tube travel is also of importance in view of the elongation of the image which occurs in the direction of the incident beam travel. It is obvious, too, that the thickness of the layer demonstrated depends also upon the distance ratio and upon the operative angle, the greater the operative angle the thinner the layer demonstrable.

A simple diagram **(860)** shows the principle on which the tomograph works, two layers being shown in an imaginary cavity to illustrate tube movement variations. For the sake of clarity two tube displacements are shown, representing one of 14 inches and one of 24 inches: demonstrating an 8 inch layer and a 5 inch layer respectively.

For each tube position only the central ray is shown from tube to film, the cone limitation of the beam being indicated briefly by broken lines, by the extension of which it will be seen that the layer of tissue at the centre of the movement remains in focus throughout.

A unit has also been devised for erect positioning in which the *patient* and *film* rotate on vertical axes while the X-ray tube remains stationary, adjustment of patient being the means whereby the variation in depth of layer is obtained: this apparatus, named the *Sectoscope*, allows for screen examination during the movement. A further development of this principle permits of other than longitudinal layers to be recorded.

The earlier tomographic units were too costly to be generally adopted, but a recently designed simple tomographic fitment for the general X-ray couch has enabled many departments to apply this technique. The principle of this horizontal fitment can be applied also to the vertical sinus or radiographic stand, and is there equally effective, which is of importance to those who possess a couch unsuitable for tomography.

Diagrams **(867)** and **(868)** show the adaptation of this fitment.

The Potter-Bucky diaphragm is used for all exposures, including chest examinations, for which latter the exposure time may be from one to two seconds, other factors being adjusted to compensate for variation in thickness and regional density. An anode-film distance of from 36 inches to 42 inches is usually employed, but in units especially designed for chest tomography this factor may be increased to 72 inches.

In lung work there is usually indication that either the anterior or posterior lung field is involved, in which case the exposures may be confined to layers at one inch intervals throughout the localised area. Lung films are exposed on normal full inspiration, care being taken to expose at the same phase of respiration for each layer, which may be checked, roughly, by observing the degree of tightening of the compressor band.

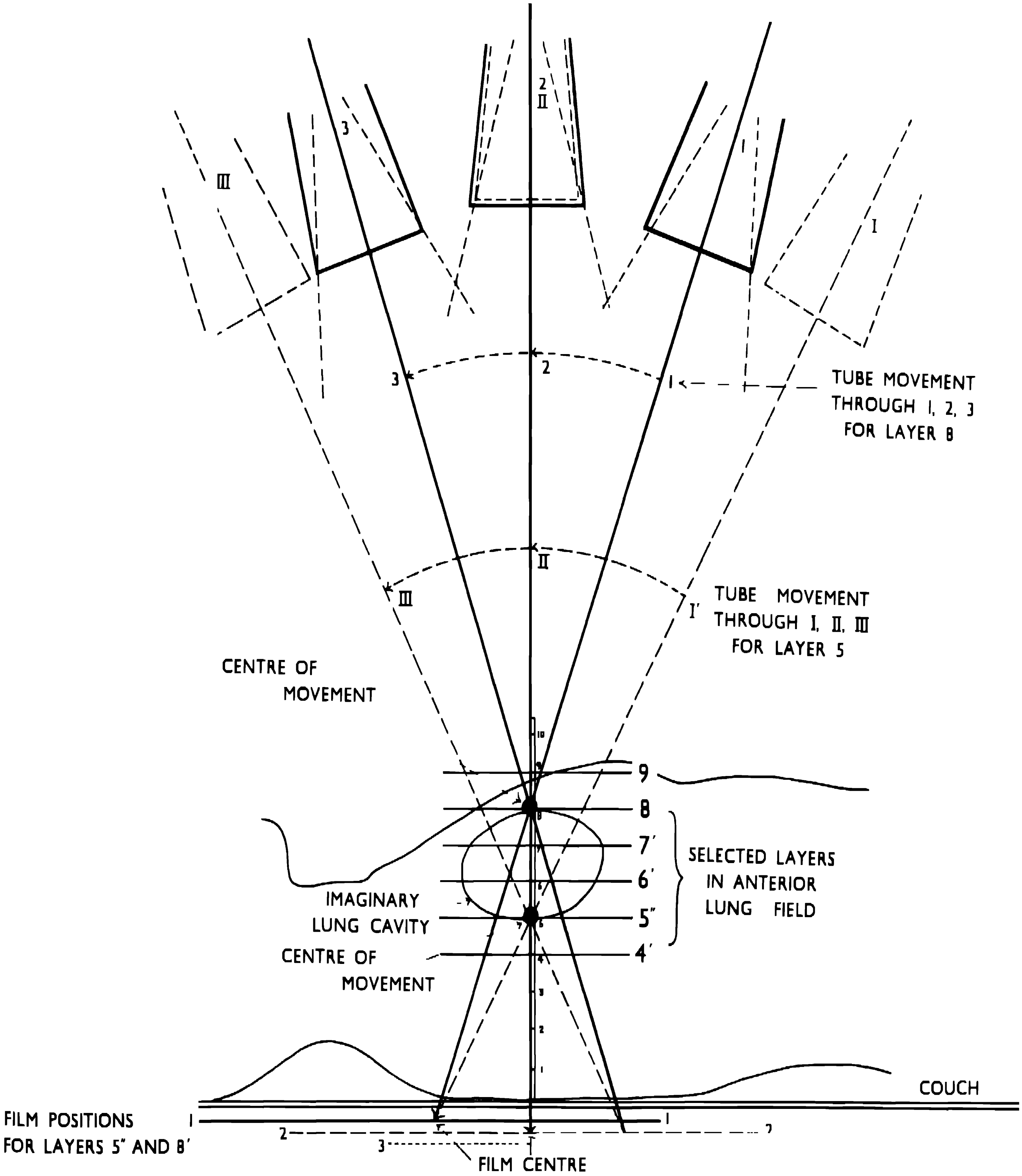

Diagram showing operation of the Tomograph.

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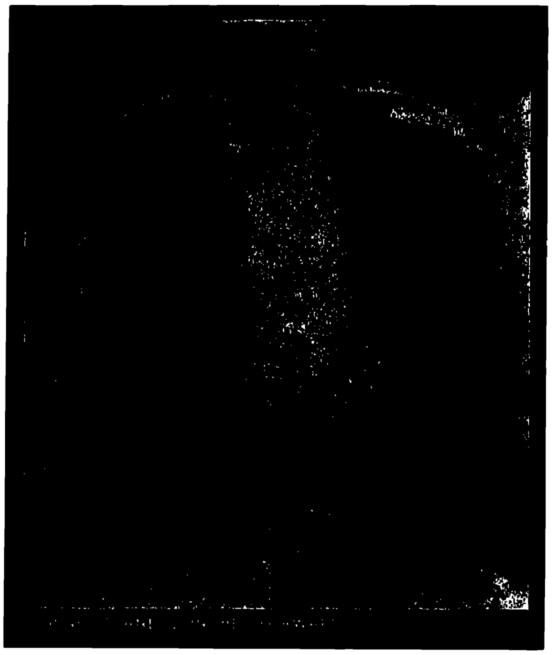

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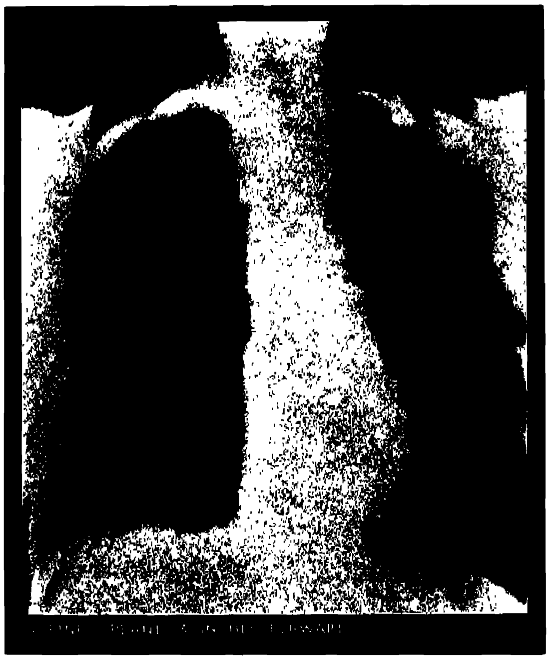

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865

866

Tomography

The lung tomographs numbered (862) to (866) were taken on inspiration, the exposure technique being in accordance with the exposure table. The patient, on expiration, measured 9 inches from the antero-posterior aspect at the level of the axilla. Radiograph (861), taken of the same patient, was exposed at 70 kilovolts, 12 milliampere-seconds, and at an anode-film distance of 48 inches.

Lung Tomographs EXPOSURE FACTORS

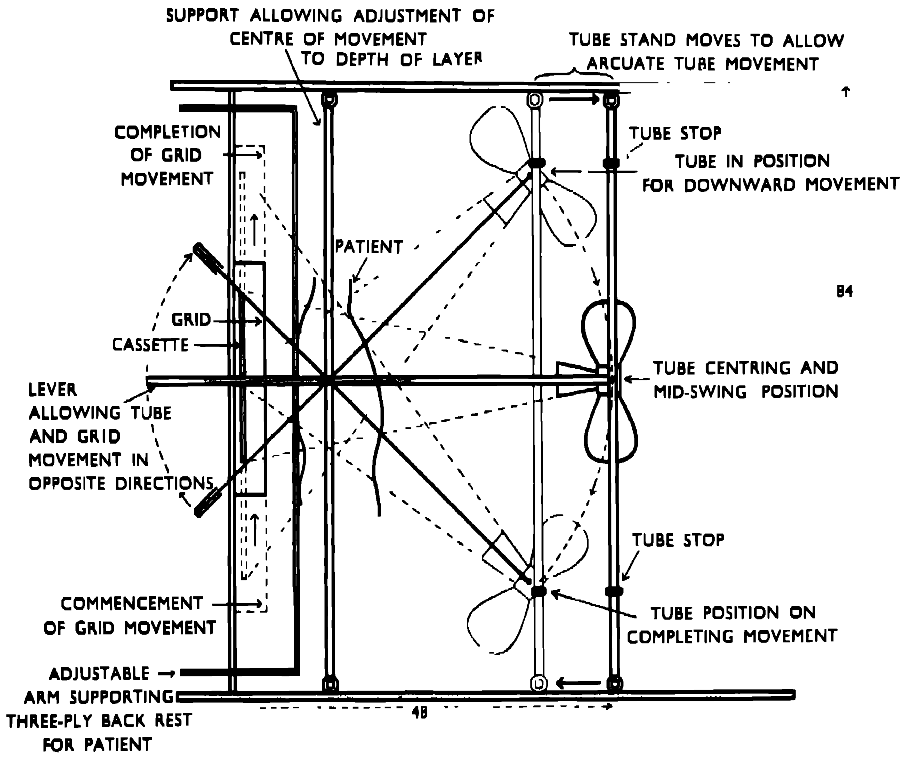
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*58	84	**50	42"	Ilford	Tungstate	Potter-Bucky

* Single valve unit. ** 50 milliamperes for one second.

An adjustment in kilovoltage should be made to accommodate subjects of varying size; and all films should be marked to show the level at which they were exposed, measured from the film aspect of the region examined.

This technique should be of value also in localising the position of foreign bodies, especially those of a less opaque nature lodged in the lungs.

Although tomography is employed chiefly for chest work, it may be applied with advantage to some of the more obscure regions of the bony skeleton.



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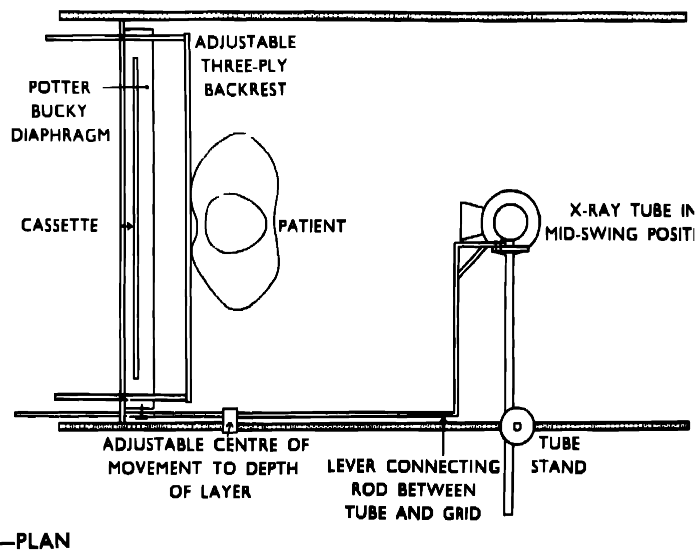
SINUS STAND—ELEVATION



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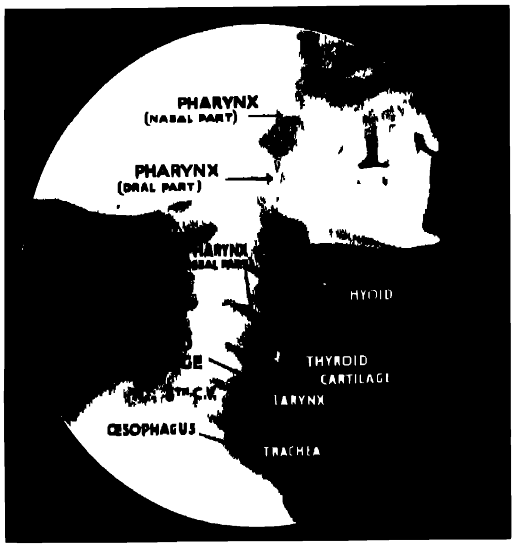
SINUS STAND—PLAN

SECTION 22

Alimentary Tract



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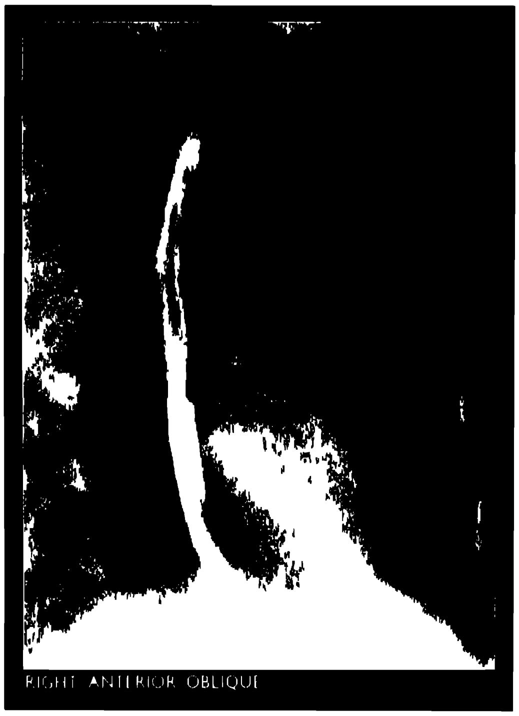

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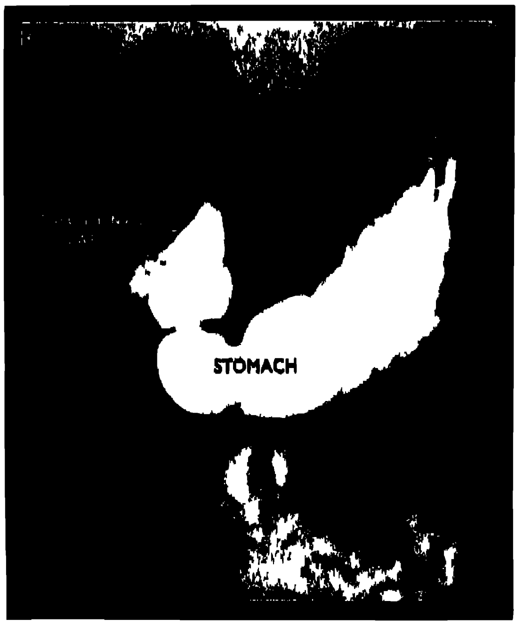

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ALIMENTARY TRACT

The alimentary tract extends from the mouth to the anus. It consists of a continuous tube having regional variations in diameter; and where there is a change of diameter there is also a change or modification of function. The chief parts are the mouth, pharynx, œsophagus, stomach, small intestine, large intestine or colon, rectum, and anus.

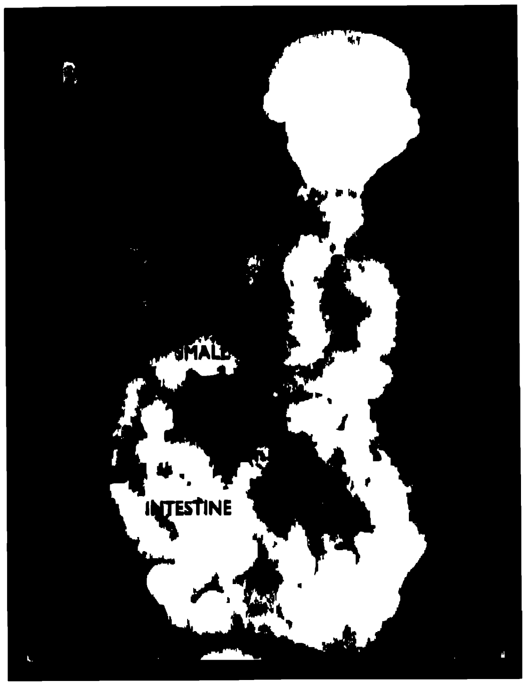
The *pharynx* or throat cavity is situated between the mouth and the œsophagus, and extends from the level of the base of the skull to the sixth cervical vertebra, the lower part only, from the level of the soft palate, serving as a passage for food (**871**). The part above the soft palate is known as the naso-pharynx.

The *œsophagus* extends from the termination of the pharynx at the lower border of the cricoid cartilage, which is at the level of the sixth cervical vertebra, to the cardiac orifice of the stomach, which is at the level of the eleventh dorsal vertebra, piercing the diaphragm at the level of the tenth dorsal vertebra (**872**).

The *stomach* is the most expanded portion of the alimentary tract, serving as a receptacle for food and having a capacity of approximately two pints. It is situated between the œsophagus and small intestine, and lies chiefly to the left of the abdomen, but varies in position, according to subject type and content, from epigastric to hypogastric level. The chief anatomical landmarks are the cardiac and pyloric orifices, the greater and lesser curvatures, and the fundus, the most "fixed" portions being at the cardiac orifice, or opening from the œsophagus, and the pylorus, where the stomach opens into the small intestine by way of the pyloric orifice.

The fundus curves above the level of the cardiac orifice and is in close contact with the inferior surface of the diaphragm. It is air-filled when the patient is in the vertical position, but may fill with food when the horizontal position is assumed (**873**).

The *small intestine*, from 20 feet to 22 feet in length and from 1 inch to 2 inches in diameter, extends from the pyloric orifice of the stomach to the cæcum, or first part of the large intestine, the ileocæcal valve being situated at the junction. The small intestine consists of three parts, the duodenum, 12 inches in length; the jejunum, 8 feet in length; and the ileum, which is 12 feet in length. At the pyloric end the duodenum, when filled with opaque meal, appears as a smooth cone or cap, hence the term "duodenal cap": it then passes backward, and turns downward on the right of the mid-lumbar region, and then,



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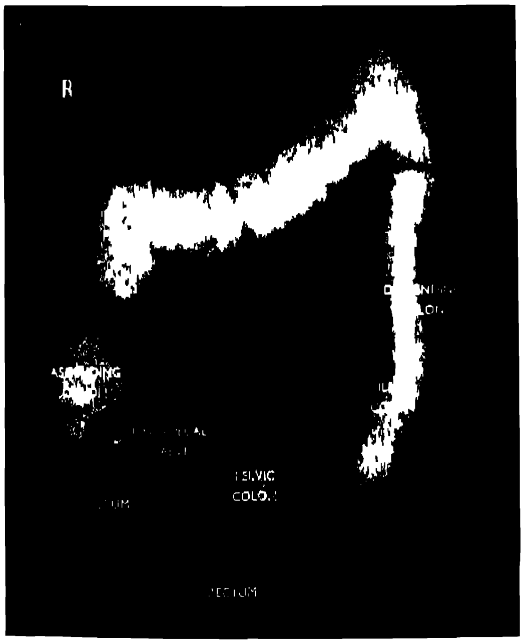


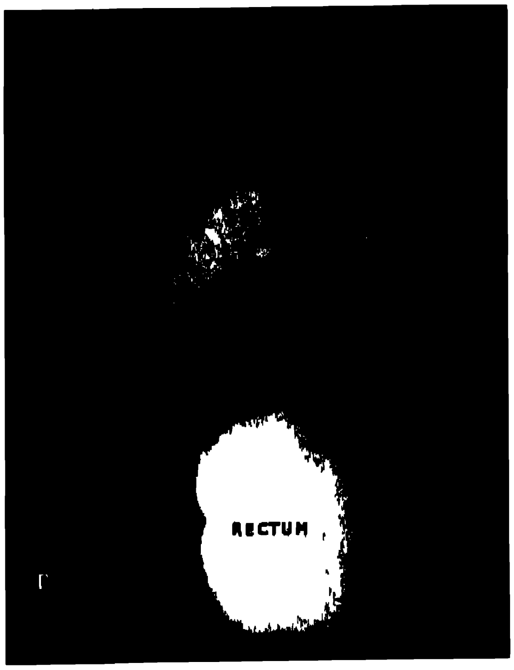
876

crossing to the left of the abdomen, again bends upward to the second lumbar level, where it joins the jejunum to form the duodeno-jejunal flexure behind the stomach. The coils of the small intestine occupy the abdomen below the level of the stomach and within the curve of the large intestine (874).

The *large intestine* or *colon* is approximately 5 feet in length and from $1\frac{1}{2}$ inches to 3 inches in diameter.

The cæcum, or blind end of the colon, is situated in the right iliac fossa: it extends $2\frac{1}{2}$ inches below its junction with the small intestine at the ileocæcal valve, and from it the appendix projects posteriorly (875, 876).

The ascending colon extends from the level of the ileocæcal valve to the under surface of the liver, where it bends to form the hepatic flexure, becoming thence the transverse colon, which passes across and upward, from the right to the left side of the abdomen, to the under surface of the diaphragm. In this region it bends again to form the splenic flexure, and from this point the descending colon passes downward on the left of the abdomen to the level of the iliac crest, where it bends toward the mid-line to become the iliac and pelvic portions of the descending colon, finally entering the rectum in the mid-line of the pelvic cavity, and terminating below at the anal canal, which connects the rectum to the anus, the external orifice of the alimentary tract (876, 877). The pelvic colon forms a loop which is often called the sigmoid flexure.



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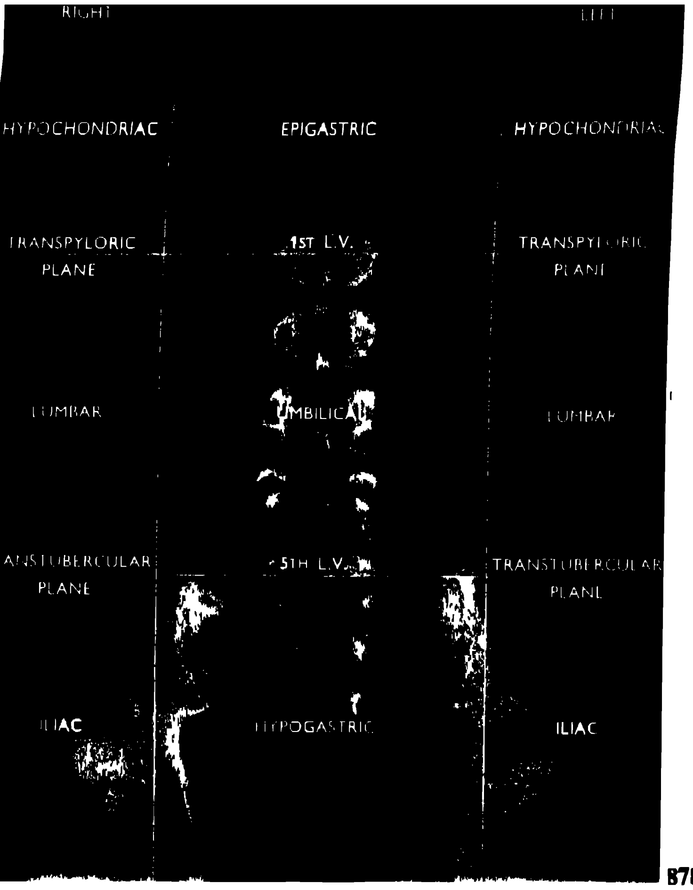

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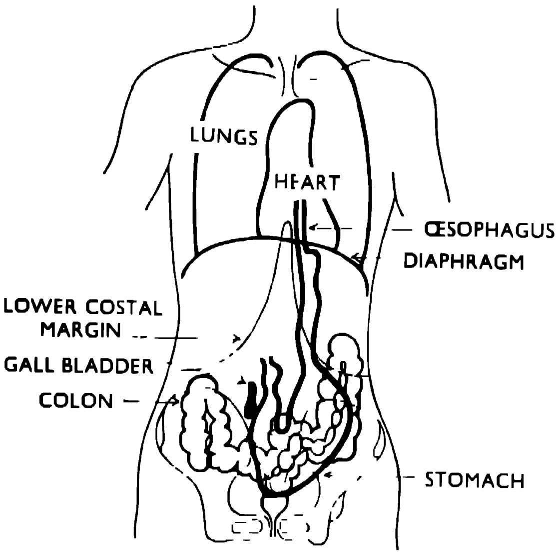

ASTHENIC

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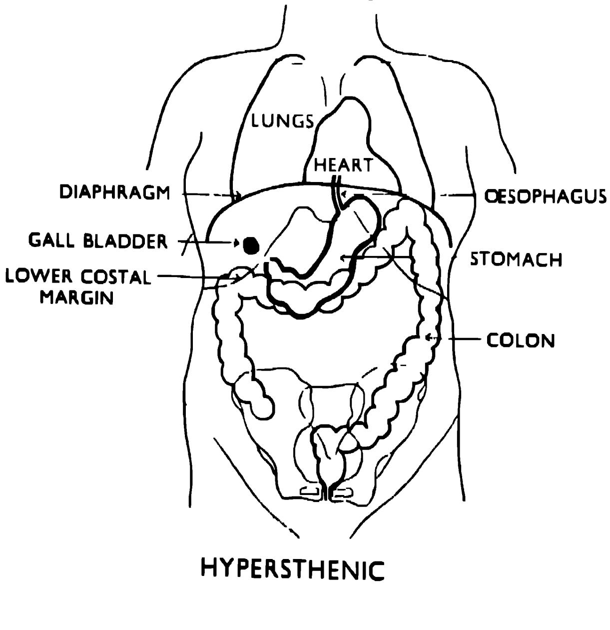


HYPERSTHENIC

880

Alimentary Tract

REGIONS

For convenience in describing the position of the abdominal organs the abdomen is divided into nine regions by imaginary lines, two vertical and two transverse. The vertical lines, which are parallel to the median line of the trunk, pass midway between the anterior-superior iliac spines and the symphysis pubis. The two transverse lines are shown at the level of the first and fifth lumbar vertebræ, being known, respectively, as the transpyloric and the transtubercular lines. An additional transverse line, known as the subcostal line, is frequently shown at the level of the third lumbar vertebra. Ignoring the subcostal line, the nine regions shown are named from above downward, centrally, epigastric, umbilical, and hypogastric, and laterally, right and left, hypochondriac, lumbar, and iliac. These lines and regions are shown in **(878)**.

The relative positions of the gastro-intestinal portions of the alimentary tract vary according to subject type as discussed on page 286, to which reference should be made. Examples of extreme types are shown in diagrams **(879)** and **(880)**.

RESPIRATION

It is necessary to consider the effect of respiratory movement on the alimentary tract--particularly the gastro-intestinal portion—as the level of the viscera varies, and radiographic positioning is, therefore, varied, on inspiration and expiration. Exposure is usually made during *arrested expiration*, when the vertical portion and fundus of the stomach tend to fill. Further, a short pause between suspension of respiration and exposure allows involuntary movement of the viscera to subside, blurring of the radiographic image being thus avoided. It should also be noted that when exposure is made during *forced inspiration* a misleading outline of the duodenal cap may be shown.

OPAQUE MEDIUM

The alimentary tract is not visible radiographically unless containing either air or an opaque medium, such as barium sulphate or bismuth carbonate. Either of these opaque media, but usually the former, is mixed with a suitable substance—arrowroot or cornflour—to form a meal, or a simple emulsion may be made with water and gum tragacanth and flavoured to taste. These preparations are obtainable under various trade names for examination of the œsophagus and gastro-intestinal tract by ingestion, or of the colon by enema injection.

881

882

OPAQUE MEDIUM *(continued)*

The radiographic examination varies for each part of the tract and is discussed in three sections, namely, pharynx and œsophagus, gastro-intestinal, and colon or large intestine.

Preparation of the patient, where necessary, varies according to the region under examination, as shown in the following pages.

SCREEN AND FILM EXPOSURES

It should be appreciated that the radiologist's fluorescent screen examination is of chief importance in the radiological investigation of the alimentary tract, films being exposed at intervals during the passage of the meal, according to special instruction or to an established routine, to confirm the radiologist's screen interpretation. The duty of the radiographer is to ensure that the apparatus is in perfect order, and that both patient and meal are adequately prepared; to administer the meal according to instructions; to care for the patient during the screen examination; frequently, to manipulate the switch table for radiographic exposures at intervals during screening; and to expose the follow-up series of films as directed, usually in the absence of the radiologist.

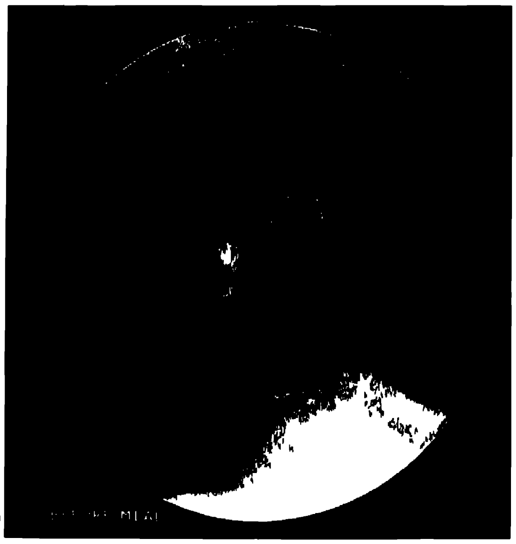
IDENTIFICATION OF FILMS

It is important that all films should be carefully identified as to name of patient, position of patient, right and left sides, and interval of exposure following the ingestion of the meal or injection of opaque enema.

SCREENS AND GRID

Intensifying screens are used to enable a short exposure technique to be applied, the fast *Fluorazure* screens being particularly suitable for this work. Films may be taken either with or without a grid, this depending on the technique adopted by the radiologist, but where power is limited, and to avoid blurring due to movement, it is better to give a short exposure without the grid. Two radiographs taken of the same subject show the differences between the grid and non-grid film **(881)** and **(882)**.

The exposure factors quoted in this section apply to an adult subject of 150 pounds weight, having a height of 5 feet 8 inches and having, at the second lumbar level, an antero-posterior thickness of 10 inches and a lateral thickness of 15 inches.



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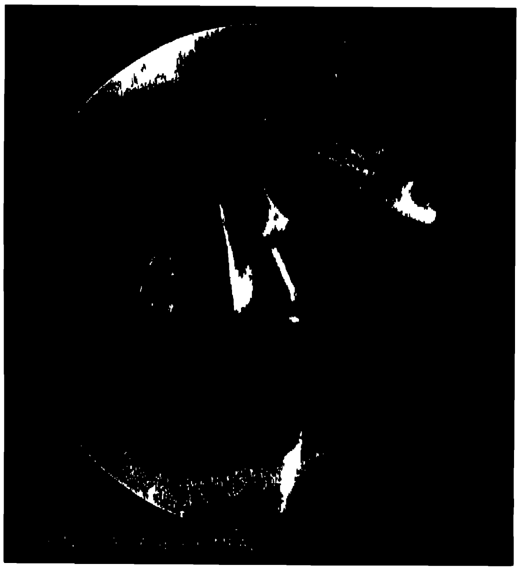


885

Pharynx and Œsophagus

The pharynx, or throat cavity, and the œsophagus are investigated chiefly by visual or screen examination. Special preparation of the patient is not necessary, except that a heavy meal should not closely precede the examination. A thick opaque meal is usually preferred, and the patient is fed by spoon after being placed in position behind the fluorescent screen. Having taken a large mouthful the patient is instructed when to swallow, and progress of the meal may be followed on the fluorescent screen, films being exposed periodically as required.

An alternative to this method is to allow the food to pass through the œsophagus against gravity, which is achieved by examining the patient in the prone position with the thorax approximately 12 inches lower than the feet. In this instance the meal, on account of the position, should be just sufficiently fluid to pass from a feeding cup through a rubber tube to the mouth. The result of feeding the patient in this manner is the securing of a really satisfactory radiographic outline of the whole length of the œsophagus. In addition to a thick meal the patient may be asked to swallow a thin meal, or clear water, or a barium biscuit or some other form of opaque preparation.

PHARYNX AND UPPER ŒSOPHAGUS LATERAL

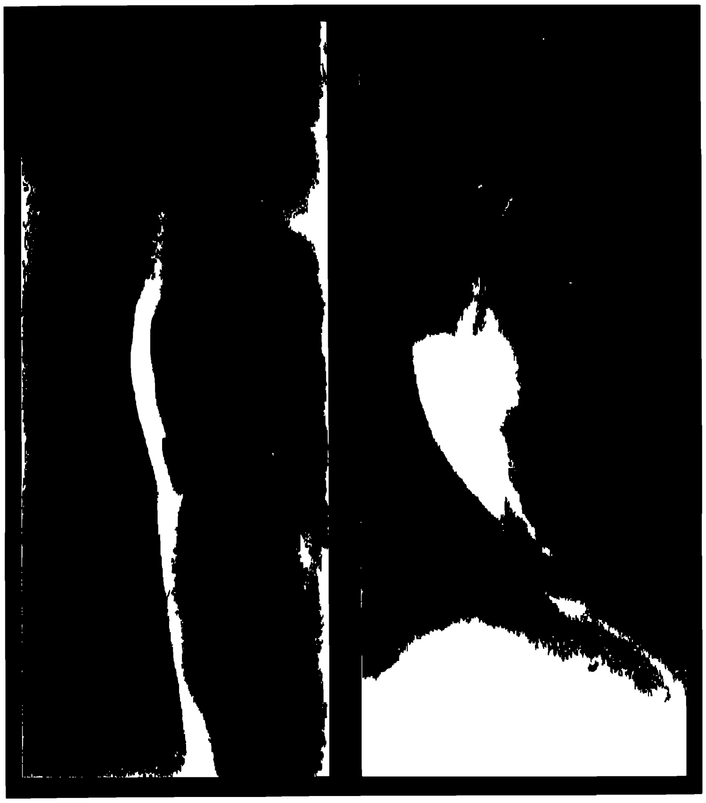
For this region the patient should be placed in the true lateral position behind the screen and a small screen aperture employed. A preliminary film is taken of the correct density to show the soft structures of the throat, a short exposure technique being employed and special immobilisation not being necessary (**883**).

The patient is then given several mouthfuls of the opaque preparation during the radiologist's screen examination: a rapid exposure may be made during the process of swallowing (**885**), but generally an interval is allowed to elapse after swallowing, exposure then being made to demonstrate whether any residue is retained (**884**). The modern automatically and quickly positioned cassette is of the utmost value for this work.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	10	6	36"	Ilford	Tungstate	—

Cone or diaphragm to area of film, 10×8 in. or 12×10 in.



886a
886b

ŒSOPHAGUS
RIGHT ANTERIOR OBLIQUE

The patient, whether prone or erect, is placed in the right anterior oblique position, the right shoulder being in contact with the screen and the left shoulder rotated away until there is a clear space between heart and spine as seen by screen examination The required angle of rotation of the trunk, which varies from subject to subject, is between 50 degrees and 60 degrees In the clear space the œsophagus is outlined by the opaque meal in its passage from the pharynx to the stomach **(886a)**

When there is a constriction present in the œsophagus one or more additional films may be taken at intervals until the opaque medium has passed the obstruction **(886b)**

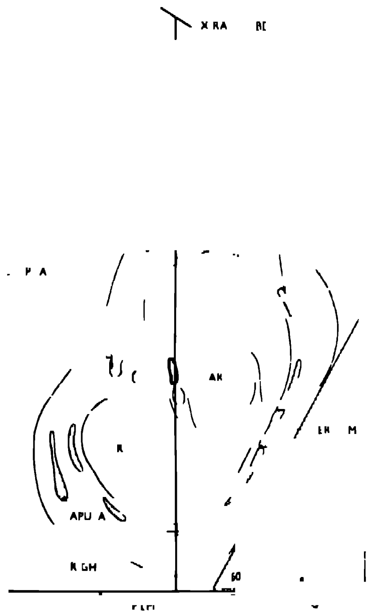
For each view the rectangular diaphragm is closed to give a narrow elongated slit in order to limit the field to the œsophagus and the structures immediately adjacent

EXPOSURE FACTORS

kVp	mA Secs	Ilford Developers X-ray Blue Label	Distance	Film	Screens Ilford	Grid
70	16	10	36	Ilford	Tungstate	

Cone or diaphragm to area of film 15 × 12 in or 17 × 7 in

The cross-sectional diagram shows the angle of rotation of the patient in the screening stand when placed for the viewing of the œsophagus **(887)**



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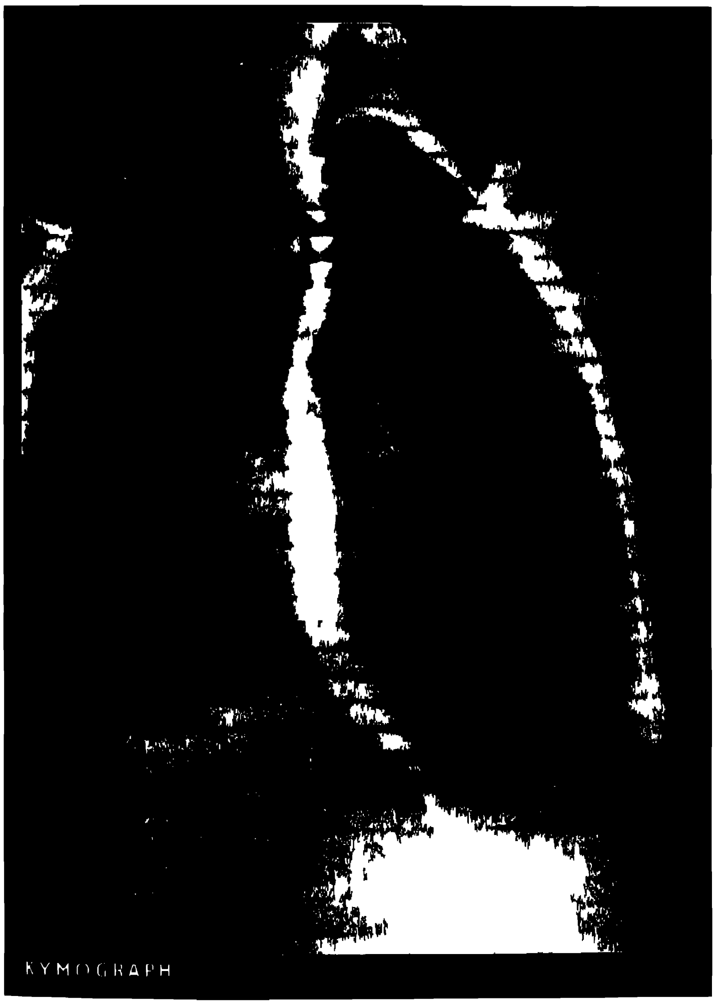
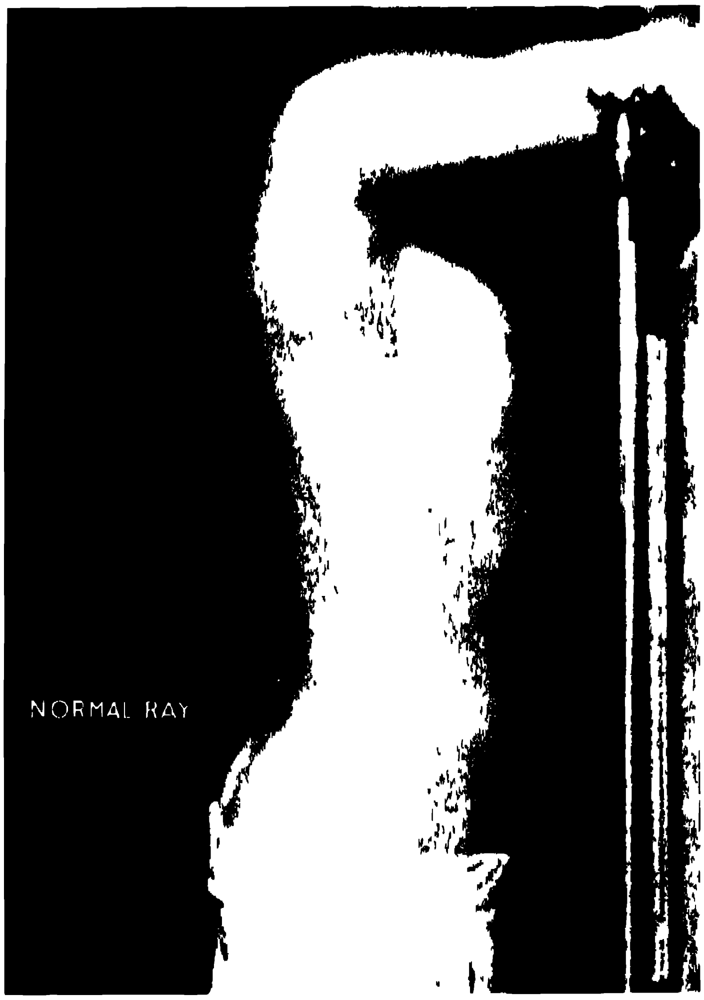


888

A kymograph of the œsophagus shows transverse movements during swallowing **(888)** Reference should be made to Section 19



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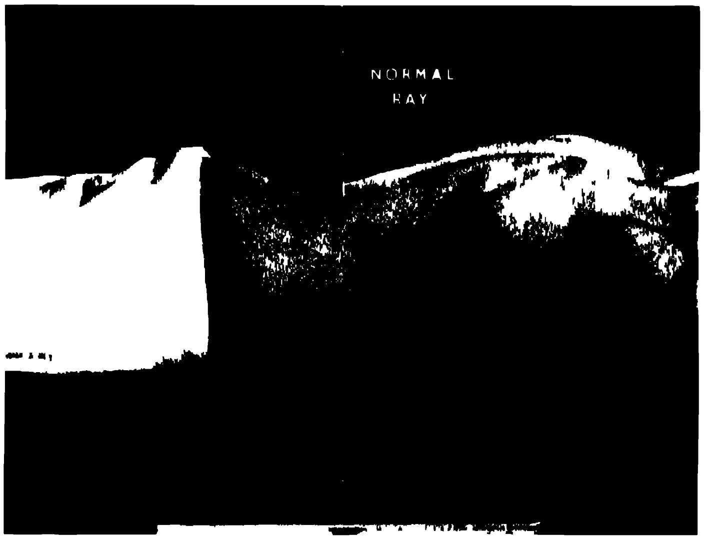


890

Alimentary Tract

Barium Meal

PREPARATION

When making an appointment for a "barium meal" examination it should be ascertained whether the patient has been taking a bismuth preparation medicinally. If so, at least three days should be allowed to elapse before the X-ray examination is undertaken, and, to avoid the possibility of the bismuth obscuring the new opaque meal, an aperient should be given on the first two nights. No aperient should be given, however, on the night immediately previous to the examination.

Many radiologists prefer to give *every* patient an aperient forty-eight hours before the examination. No change in diet is necessary, but the patient should fast, both as regards solids and fluids, for at least six hours before the commencement of the X-ray examination.

The patient should be warned that the examination will take possibly as long as six hours on the first day, with a possible extension, if further investigation is found to be necessary, up to, perhaps, twenty-four hours or forty-eight hours, or longer, according to radiological findings.

SINGLE AND DOUBLE MEAL TECHNIQUE

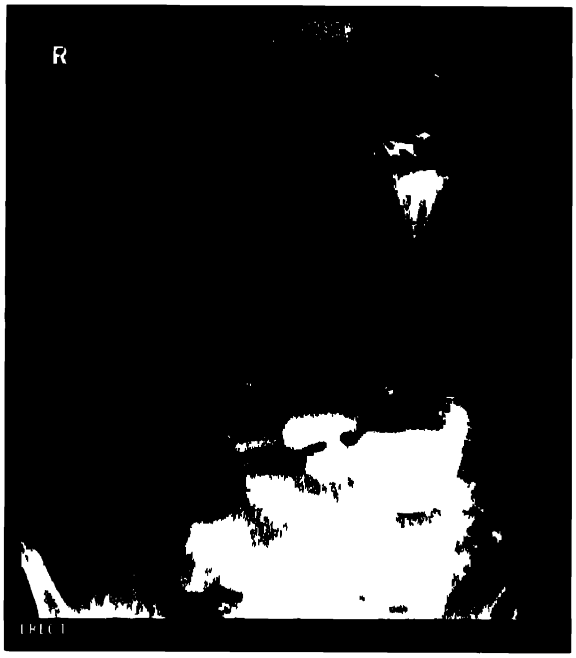
In all investigations of the stomach the initial screening includes examination of the œsophagus.

In "single meal" technique the patient is screened during the taking of a small portion of a 20 ounce opaque meal; the remainder of the meal is then given, immediately following which the first film is exposed, this being followed in turn by a succession of films of the stomach and duodenum, taken at varying intervals.

In what is known as "double meal" technique the *full* 20 ounce meal is given, and screening is delayed until after the taking of a series of films at intervals during the emptying of the stomach, which may cover a period of four hours or more, a *further* small meal of from 2 ounces to 4 ounces being administered during the delayed screen examination.

GENERAL FILM SERIES

Following the immediate and duodenal exposures films may be taken at thirty minutes, one hour, and two hours, or this last film may be taken at three hours. The most important films of the stomach are taken within the first three hours, but a five-hour or six-hour film is usually taken to ascertain whether the stomach has emptied within what is considered to be the maximum normal emptying period. Should only the stomach and



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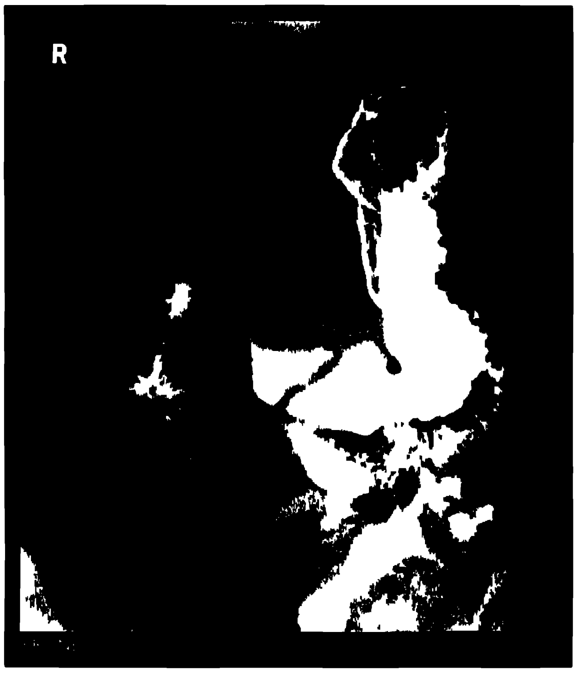

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893

Alimentary Tract: Barium Meal

GENERAL FILM SERIES *(continued)*

duodenum be under investigation examination is terminated when the stomach is empty, which may occur at three hours or less, later films being then unnecessary.

Usually the whole of the gastro-intestinal tract is investigated, in which case the six-hour film is essential to show the progress of the meal through the small intestine and the filling of the cæcum.

The large intestine may be shown in films taken at six hours, twelve hours, twenty-four hours, forty-eight hours, and sometimes later, after the ingestion of the opaque meal **(901, 902, 903)**.

The series of films **(896 to 903)** shows the progress of the meal from the stomach to the large intestine, and an additional film **(904)** shows the appearance of the colon in the same subject following a barium enema, and should be compared with the twenty-four-hour film **(902)**.

POSITIONING

The gastro-intestinal tract should be examined in the erect, the horizontal, or the semi-recumbent position, but it is usual to take at least the first film in the erect position because the type, tone, and relative position of the stomach is then better appreciated and the stomach falls to its lowest level **(891)**. In the horizontal position the fundus changes little, but the pyloric end moves well up to the right and the barium meal flows up toward the fundus, which it fills **(892, 893)**.

Many radiologists prefer to have films taken in both the erect and prone positions throughout the examination.

In the horizontal position the series of films is taken with the patient prone **(892)**, although the screen examination may be made from either supine or prone aspects or both. In the supine position, however, the stomach may divide over the ridge formed by the spinal bodies so that the general outline is not shown, although the fundus is well filled **(893)**. Occasionally, in a very thin subject a similar appearance may be shown with the patient in the prone position, when pressure should be relieved by placing wool pads under thorax and pelvis.

In any of these general postures abnormal conditions may be found to necessitate the taking of films of the abdomen from any or every possible aspect, including right and left lateral and right and left oblique. Reference should be made to stomach, postero-anterior **(894)** and lateral **(895)**; to duodenum, postero-anterior and oblique **(907, 908)**; and to colon, postero-anterior and oblique **(920)** to **(923)**.

894

895

STOMACH
POSTERO-ANTERIOR

In the erect position the radiograph is frequently taken following the screen examination, so that the position of the stomach is known and can be noted for later films should these be taken without further screening (889).

In the prone position the film, when of the 12 inch by 10 inch size, is placed with the lower edge level with the anterior superior iliac spine and slightly over toward the left side (890).

CENTRE at the level of the transpyloric plane, toward the left of the spine.

It is sometimes necessary to radiograph the stomach with the film placed transversely in relation to the abdomen, as the stomach may be very high up under the diaphragm and shallow in depth. This may occur in either the erect or the horizontal position (905, 906a).

The size of the film, whether 15 inches by 12 inches or 12 inches by 10 inches, depends on the size and position of the stomach. The larger film is usually required for the thin subject having a long and low stomach, the smaller film sufficing for the small, high stomach, usually found in the thickset patient (905, 906, 906a).

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	25	15	30″	Ilford	Tungstate	—
80	33	20	30″	Ilford	Tungstate	Potter-Bucky
80	25	15	30″	Ilford	Fluorazure	Potter-Bucky

Cone or diaphragm to size of film, 12×10 in. or 15×12 in.

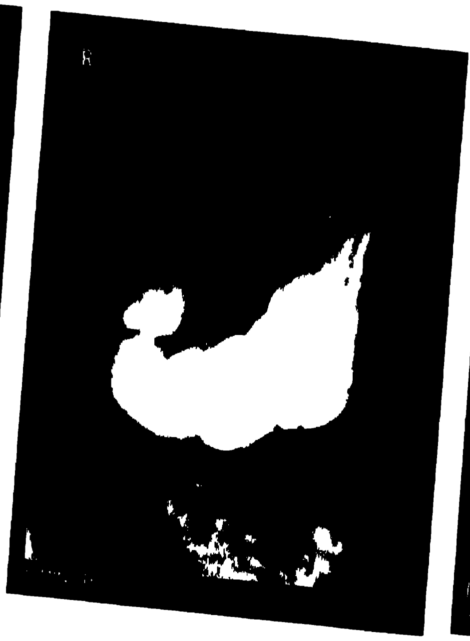
The value of additional oblique and lateral views of the stomach is emphasised by radiographs (894), postero-anterior view showing a gastric diverticulum (single arrow) and a diverticulum at the duodeno-jejunal flexure (double arrow), and (895) the lateral view of the same patient, showing the diverticula with their stalks in profile.

DUODENUM

This part of the examination embraces a series of views of the duodenum taken in quick succession and from various angles, as soon as the duodenum is seen to be functioning satisfactorily after ingestion of the meal (907).

These films may be taken either with the modern serial apparatus which, after screening, permits of automatic and simultaneous positioning of the film and exposure, or

896



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905


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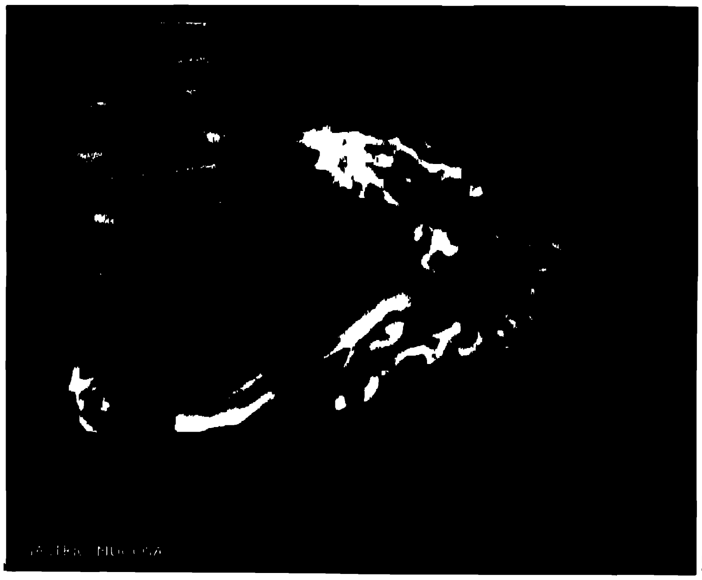
906a

DUODENUM *(continued)*

with the older type of accessory consisting of a sheet of 3 millimetre lead with a small central aperture. This latter method, however, leaves much to be desired, as without pre-exposure screening there is no certainty that the duodenum will be shown in any of the exposures. By the former method each phase of the duodenum is seen immediately before making the exposure, so that any stage during filling and emptying may be recorded. A series of small half-plate films may be employed, or with certain units a number of exposures may be made on a single 15 inch by 6 inch or 10 inch by 8 inch film.

It should be noted that on reducing the tube diaphragm aperture for the small duodenal film the penetration should be increased by at least 10 kilovolts.

The importance of oblique views is demonstrated in (908a, b and c), which show the appearance of ulcer niches from various aspects.

MUCOSAL RELIEF TECHNIQUE

In examining the mucosa or inner lining of the gastro-intestinal tract a method of localisation and compression is used which is applied particularly to the stomach and duodenum, but which may also be applied to any portion of the tract. A tilting couch which permits of movement from a modified *Trendelenburg position, at 15 degrees to 30 degrees, to the vertical position, is essential. In some couches a lateral rotation is also provided. In the older type of apparatus a small fluorescent screen is mounted between two plate boxes carrying a number of $6\frac{1}{2}$ inch by $4\frac{3}{4}$ inch cassettes, but, as already stated, more recent fitments render possible the making of a number of exposures on a single 15 inch by 6 inch film.

To the under-side of the screen is fixed a small localising cone with a compression pad attached. The position of screen, film and cone, which are automatically centred to the tube, is readily varied, and any suspected abnormality seen on the screen may be filmed immediately. The small screen may also be replaced by a full-sized screen if desired.

The patient takes a thick opaque meal, ingesting only a small mouthful at intervals as indicated by the radiologist, who also controls the degree of compression applied. When the radiologist is satisfied that he has all the information that can be obtained by this localised screening, a full meal is given and the normal series of films taken.

* Trendelenburg position, *i.e.*, with the patient supine, the foot of the table is raised until the pelvis of the patient is considerably higher than the shoulders.

907

908

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910

Alimentary Tract: Barium Meal

GASTRIC COMPRESSION

The examination is begun with the patient supine. After the entry into the stomach of the first mouthful of the opaque meal has been observed on the screen the couch is tilted into the Trendelenburg position for the examination of the cardiac portion of the stomach, the patient being gradually turned into the prone and right and left lateral positions in order to obtain a good distribution of the medium over the *fundus*. The patient resumes the supine position, and the couch is gradually tilted into the vertical position, the opaque medium being guided and distributed over the mucosal surface by the palpating hand. In order to obtain a uniform distribution of the medium it is usually necessary to repeat several times the tilting of the patient between the vertical and the horizontal and also his movement to the prone and right and left lateral positions. General and localised views with compression cone in position are then made as necessary **(905, 906, 906a)**.

DUODENAL COMPRESSION

Compression technique is also applied to the examination of the duodenal cap. There are two methods:—

(a) Compression is applied to the cap to show the mucosal relief or the presence of a niche, and, screen examination having determined the position and degree of compression giving the most satisfactory demonstration, a series of exposures follows.

(b) By the second method, for which specially adapted apparatus is necessary (the film moving across the screen and exposure being made automatically), compression is applied until mucosal relief or a niche is shown under optimum conditions, on attaining which the exposure is made **(907, 908)**.

In general, the best two positions for demonstrating the cap are the right anterior oblique and the left anterior oblique, the former showing the ulcer-bearing surfaces *enface* **(908a, 908b)** and the latter in profile **(908c)**. The latter position is the more important as it facilitates the exact localisation of the ulcer—whether on the anterior or posterior wall of the cap **(908)**.

SMALL INTESTINE

The methods applied for the examination of the stomach and duodenum do not suffice for the detailed investigation of the small intestine, as the intermittent entry of varying amounts of the opaque medium does not, as a rule, enable a continuous record to be secured.

In order to obtain a complete picture the "fractional filling" method is employed. The patient takes a large

911

912

SMALL INTESTINE (*continued*)

mouthful of the opaque meal every ten to fifteen minutes; the progress of the medium is observed on the screen, palpation assisting the desired distribution of the medium, and films are exposed, with or without compression, every half-hour until the outline of the whole of the tract from duodenum to ileocæcal valve has been recorded.

Even by this method there may sometimes be a flooding of the distal coils of the ileum, and in such cases this oral method may be supplemented by an opaque enema examination. The ileocæcal valve is usually patent in the fasting patient, and the opaque enema will usually fill the distal coils satisfactorily for demonstration. In using the enema it may be necessary to apply a raised pressure.

APPENDIX

After ingestion of the meal the appendix may be seen at six hours to forty-eight hours, or even later. The radiologist may make a screen examination several times during this period - usually at nine hours, twelve hours, twenty-four hours, or forty-eight hours **(909)**.

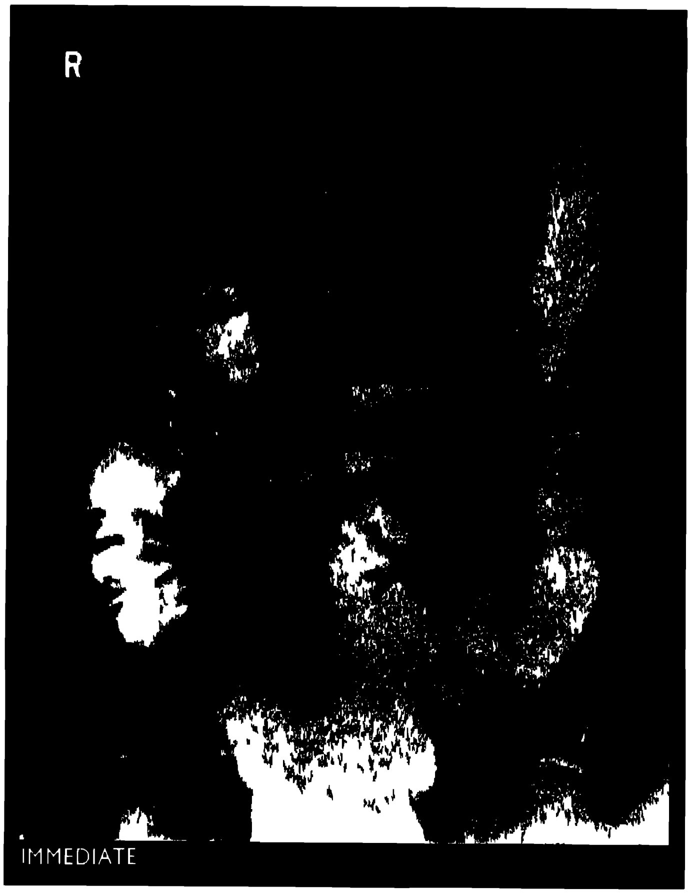
The taking of stomach films is not always included, in which case the meal is given nine hours before the commencement of the appendix examination.

When the appendix does not fill with medium the patient may be given a barium meal containing two teaspoonfuls of magnesium sulphate on three consecutive nights; the X-ray examination is made twelve hours after the third meal and may be necessary again at eighteen hours, and at twenty-four hours after the meal **(910)**. The posture should also be varied; and films on forced inspiration and expiration are of value in demonstrating the range of movement of both the cæcum and the appendix. The use of a localising cone and small films is recommended.

COLON

As has already been stated, the colon is shown by screen examination and in films taken at intervals following the stomach examination.

At six hours after ingestion the meal is seen in the cæcum; at twelve hours the ascending colon and hepatic flexure are usually visible, with, probably, the transverse colon and splenic flexure; and at twenty-four hours the whole of the colon, from cæcum to rectum, may be seen clearly outlined. At forty-eight hours the colon is usually almost empty again, and the meal may, indeed, have been completely evacuated. Great variation may be shown in the filling and emptying of the tract and the varying cases still be regarded as being within normal limits.
(901, 902, 903)



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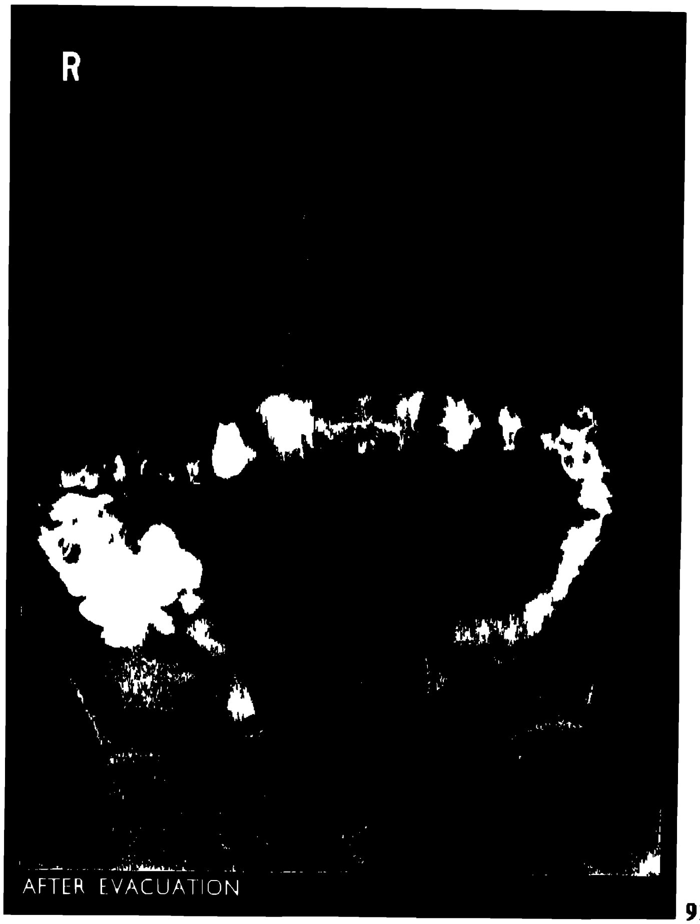

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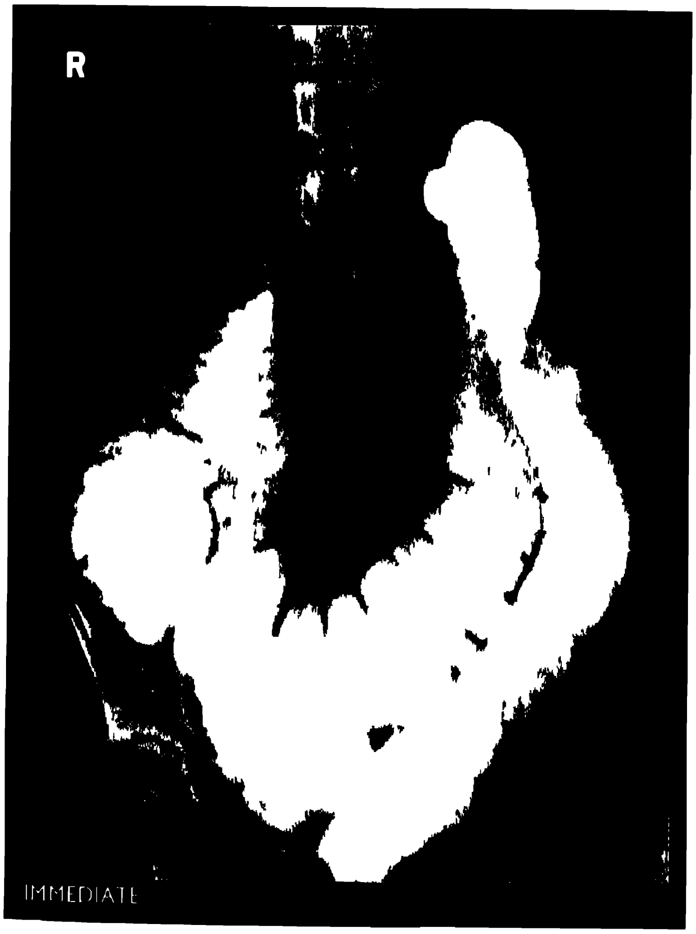

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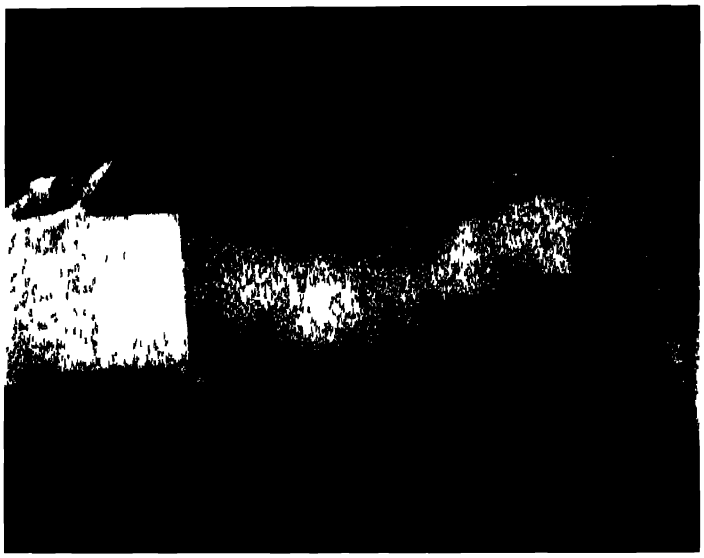
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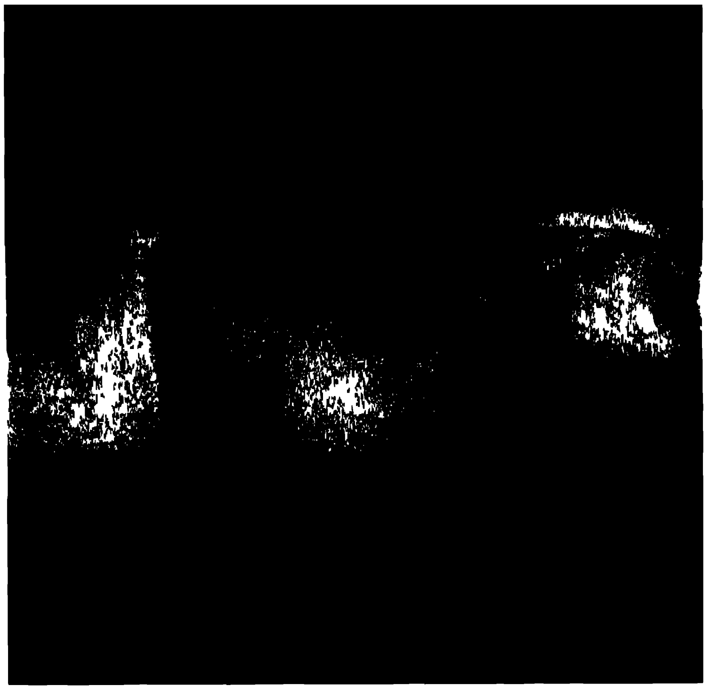
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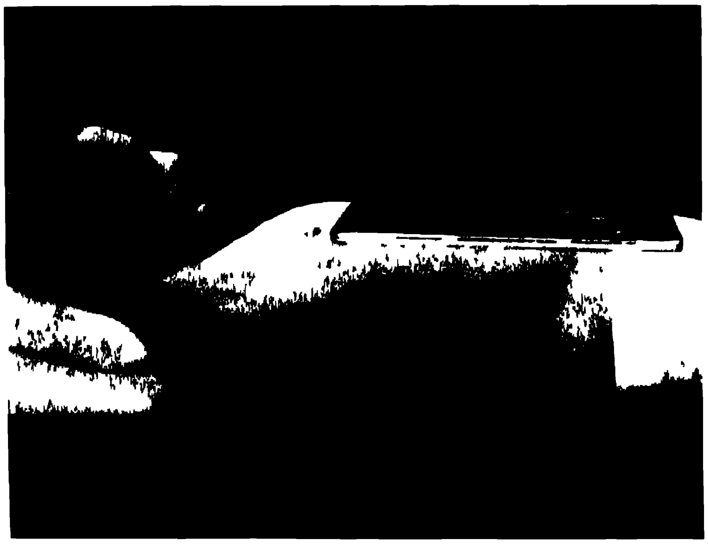
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COLON *(continued)*

Certain abnormal conditions, such as the presence of diverticula, indicate the necessity for the exposing of films beyond the forty-eight hours period and until such time as the colon is completely evacuated (911, 912).

It is usually considered to be more satisfactory, however, to examine the colon by means of a barium enema.

An exposure table for colon examination is shown on page 350.

Barium Enema

PREPARATION

The patient is given twelve to forty-eight hours' preparation according to the established routine of the individual X-ray department.

During the day preceding the examination the patient is placed on a low residue diet, and a plain water flush may be ordered to be given in the morning and evening.

It may be sufficient to give a plain water washout the evening before the X-ray examination, using a tube and funnel, and continuing the operation until a clear fluid return is obtained.

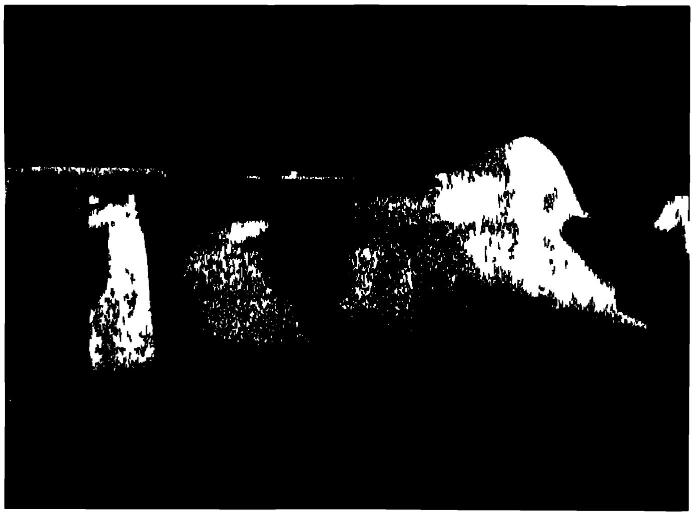
If the examination is to be made in the morning the patient may take a light breakfast. If the examination is to be made in the afternoon the colon washout may be given early in the morning, and the patient may then take a light lunch, but no breakfast.

A preliminary film taken on the Potter-Bucky couch will disclose the degree of preparation of the colon: when this is shown to be unsatisfactory further preparation should be arranged.

In preparing the enema the greatest care should be taken to ensure that the fluid is of the right consistency, is free from lumps, and is used at body temperature. A fine sieve or piece of gauze should always be used to filter the enema.

The enema container, holding at least three pints, should be of glass and be graduated so that progress may be observed. The container may be suspended on a counter-weighted pulley or may be adjustable on a series of pegs at varying heights so that the level of the container may be altered as required. A glass connection between the rubber tube and the catheter is essential in order that the flow of the enema may be observed at intervals during the injection.

Immediately before inserting the catheter a small quantity of the fluid should be allowed to run through, and the end secured with a clip, thus ensuring that the enema is running freely and that air is excluded. A second clip serves to control the flow of the enema after



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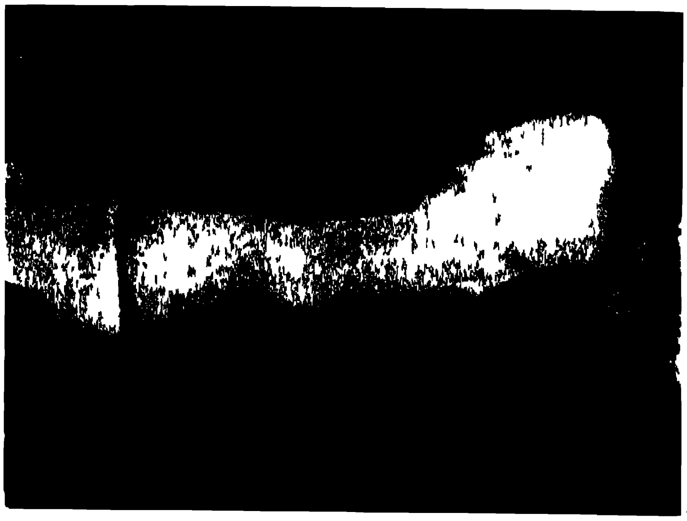
RIGHT ANTERIOR OBLIQUE



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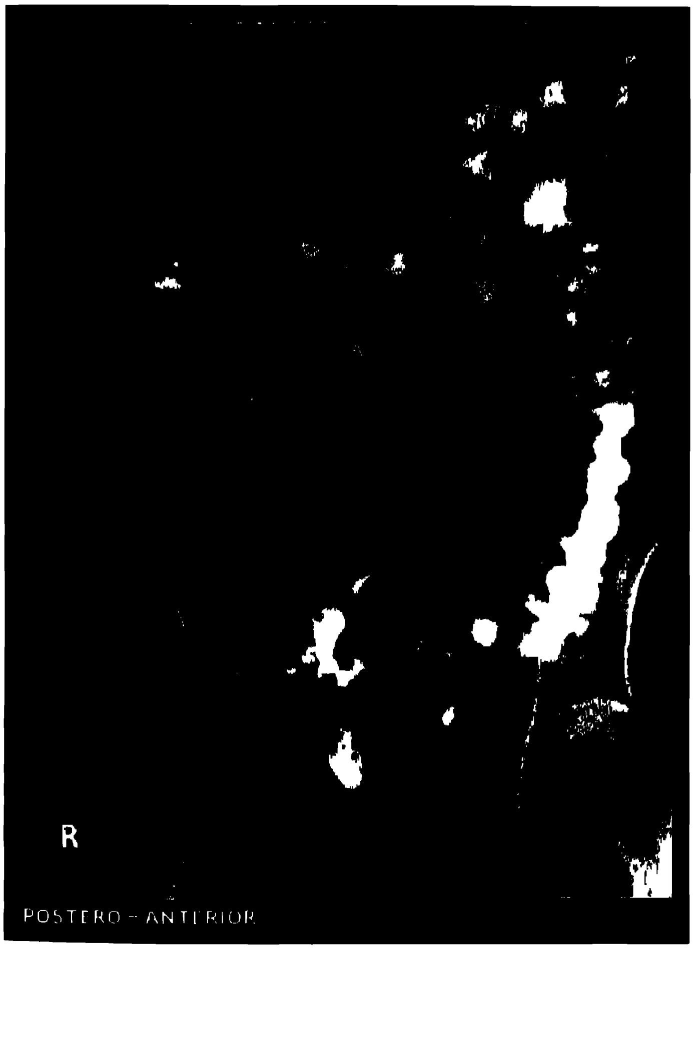
LEFT ANTERIOR OBLIQUE



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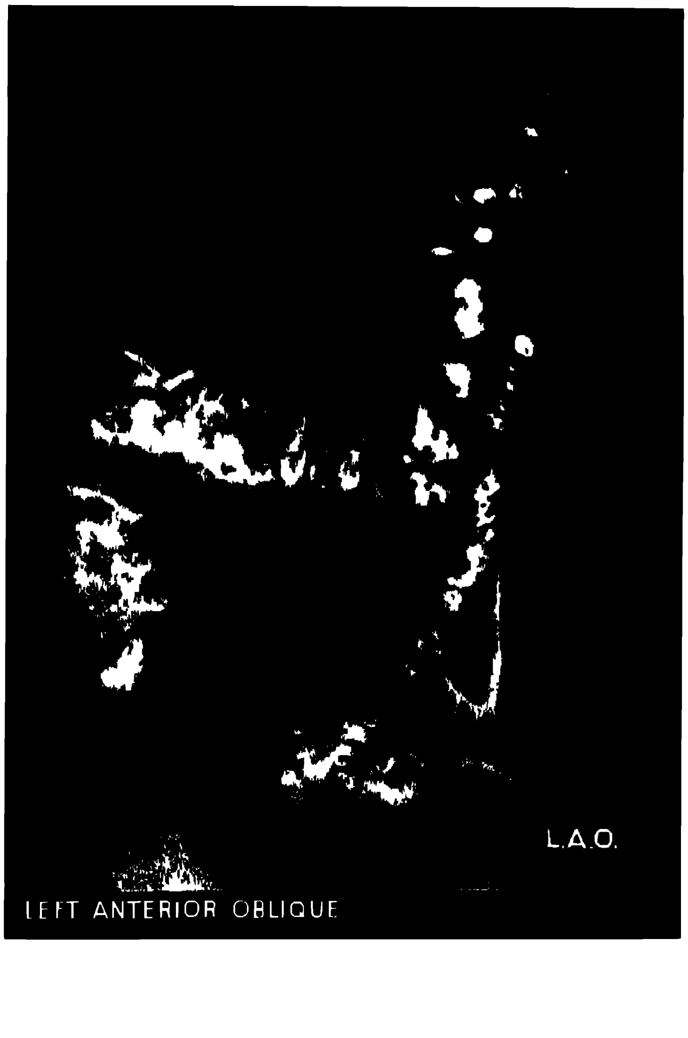

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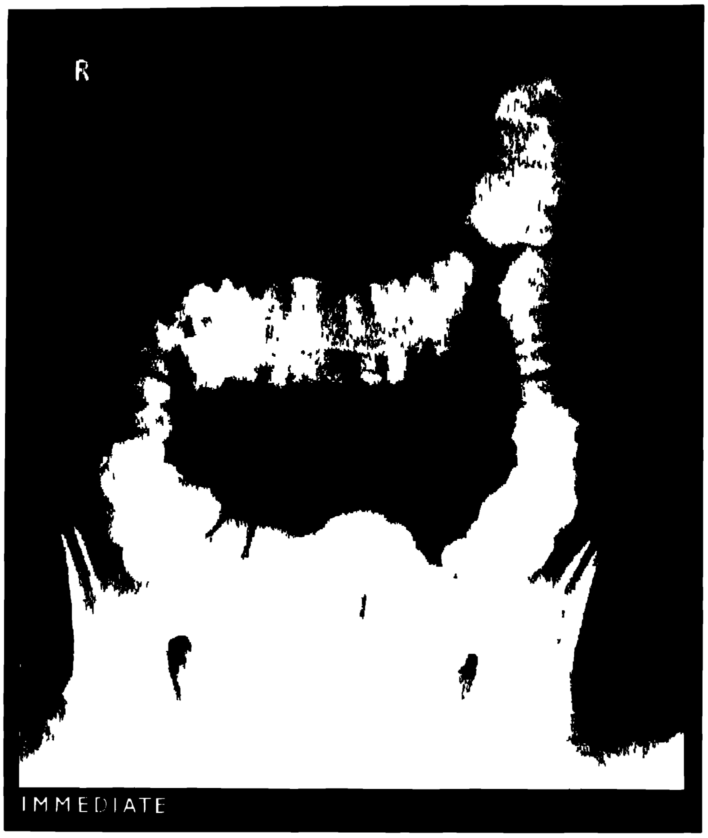

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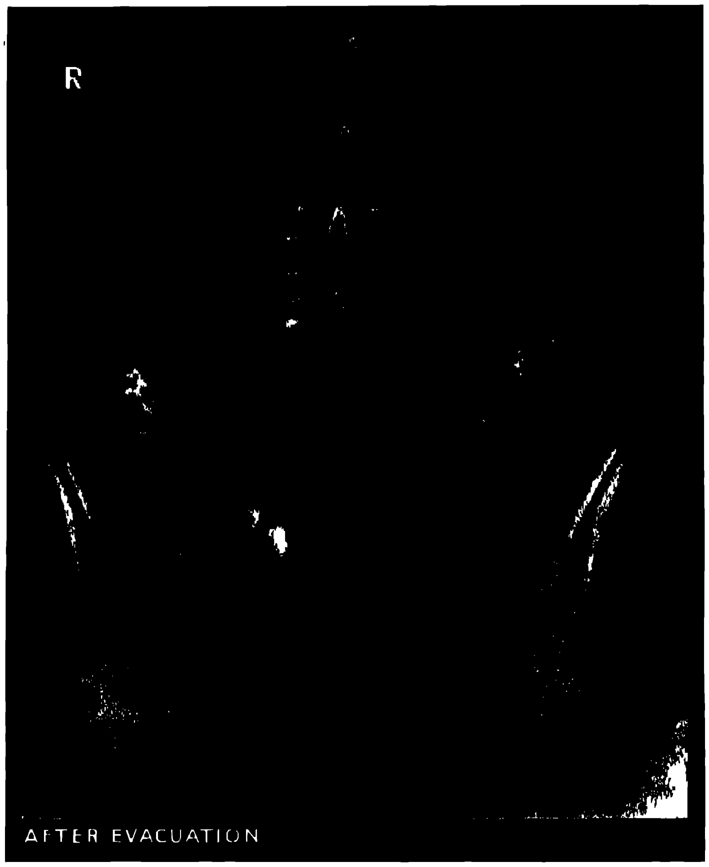

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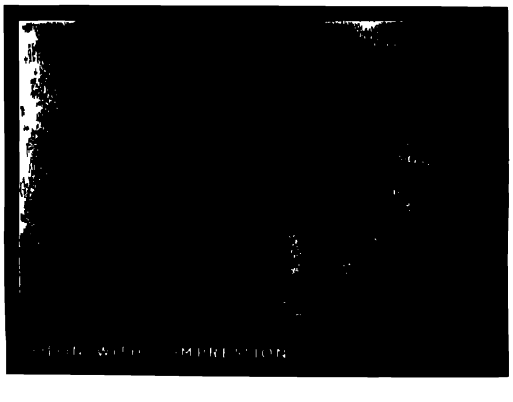
926

Alimentary Tract: Barium Enema

PREPARATION (*continued*)

the catheter has been inserted into the rectum. Plenty of cellulose and a bedpan should be in readiness.

It is necessary to give the patient a brief explanation as to the procedure and to request collaboration: this will give reassurance to all patients and ensure the co-operation of most.

POSITIONING AND INJECTION TECHNIQUE

The patient is placed on the screening couch, in the lateral position and, the anus and catheter having been prepared with a little medicinal paraffin, the catheter is gently inserted well into the rectum, but not so far that the open end presses against the wall of the rectum or so as to cause the catheter to bend back on itself, in either of which cases the flow of the enema will be obstructed. A brief screen examination to show the position of the catheter is advisable before the second clip is released for the enema to flow.

For the patient's comfort wool pads should be placed under the lower spine and also under the upper and lower edges of the fluorescent screen when, as is the method in some departments, the heavy screen is allowed to rest directly on the patient instead of being suspended immediately above.

The filling of the colon is viewed by the radiologist, who indicates when the flow of the enema is to be arrested, the positions in which the films are to be exposed, and the intervals at which they are to be taken.

In the early stages of the injection, when the rectum is fully distended, discomfort to the patient should be avoided by stopping the flow until the enema commences its passage into the pelvic colon when discomfort will lessen, and, with the patient reassured during this first stage, a satisfactory complete filling may usually be obtained.

If the enema is slow in moving round the colon the foot of the table should be raised, and when the medium is seen to be leaving the rectum the patient should be turned toward the left side, and later, when it is seen to have reached the splenic flexure, toward the right, thus assisting the flow to continue across the transverse colon to the hepatic flexure and ascending colon.

SUPINE OR PRONE

After screening, and with the catheter retained in the rectum, the patient is gently turned from the supine to the prone position for the "immediate" film, which may be exposed with the tube either below the couch **(917)**, or above, with the Potter-Bucky diaphragm **(918)**. Immediate and evacuation films are shown on page 343.

(913, 914, 915, 916)

927

928

SUPINE OR PRONE (*continued*)

The prone position allows the sections of the colon to converge slightly toward the mid-line, thus enabling the whole to be shown on a single film, which is of special value in large subjects, while at the same time division of the colon over the spine is usually avoided. It should be noted, however, that there is frequently better separation of redundant or overlapping coils of the colon with the patient in the supine position (**919**). For exposure factors reference should be made to page 348.

With very broad patients it may be necessary, in either of these positions, to expose two separate films to show the whole of the colon, a large film being placed transversely (**927**) to cover the upper abdomen, and a smaller film longitudinally (**928**) to include the rectum and pelvic colon.

Additional films taken in the right and the left anterior oblique positions are frequently required, as they assist in giving a complete outline of the colon in cases in which other views show two regions overshadowing each other.

RIGHT OBLIQUE

The patient is rotated toward the *left*, the right side being raised through an angle of approximately 40 degrees to the horizontal, in which position the screen shows the transverse and ascending colon separated on the right side. The film is rested on the patient's right side and supported parallel to the couch (**920**).

LEFT OBLIQUE

The patient is rotated toward the *right*, the left side being raised. Screening may be employed to ensure separation of redundant coils of the colon on the left side. The film is exposed as for the right oblique view, to show clearly the splenic flexure and separation of transverse and descending colon (**921, 923**).

Two radiographs taken of the same patient show (**922**) the prone position, with the transverse and descending positions of the colon overlapping, and (**923**) the left anterior oblique position with these two portions of colon separated.

EVACUATION

Most patients can be induced to retain the enema until the series of exposed and developed films have been seen and approved. The enema can then be evacuated, and further films taken. It should be possible to syphon back a part of the enema, as required.

All patients, however, do not evacuate freely: in cases of delayed evacuation the exposing of the evacuation film should be delayed until the state of the patient permits but not beyond half an hour. It will be found, in

929

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930a

EVACUATION (*continued*)

taking these films, that the colon can be included on a much smaller film area than was possible when the colon was distended with the opaque medium (**924, 925**), and also (**913, 914, 915, 916**).

A thin residue coating of enema shows the lining of the colon (**925**), and any irregularities rendered visible may then be further investigated, palpation and compression being applied as for the stomach and duodenum (**926**).

Depending on the condition being investigated, the examination may be extended up to forty-eight hours, or longer.

When the question of diverticula arises it is essential that the examination should be continued until the colon is empty. This may be for ninety-six hours or more, films being taken at twenty-four-hour intervals (**911, 912**).

AIR INFLATION

When other methods have failed to determine the degree of distensibility of any portion of the bowel, inflation by air is employed. It is not, however, a routine method, and is only resorted to when other means have not disclosed the condition of the intestine. A Higginson's syringe may be used, or preferably a sigmoidoscope bellows, this latter giving the radiologist a finer control of the introduction of the air, screen observation being made during the operation. Films are exposed as required.

This method is illustrated in (**929**), showing distension by opaque enema; in (**930**), which shows partial evacuation of the enema, both of these revealing a filling defect; and in (**930a**), in which air inflation shows the colon to be normally distensible at the site of the filling defect, the presence of a barium coated polyp also being demonstrated.

Special conditions may necessitate a departure from normal procedure. The colon may be very large and atonic, in which case as much as three times the normal quantity of enema may be required (**927, 928**).

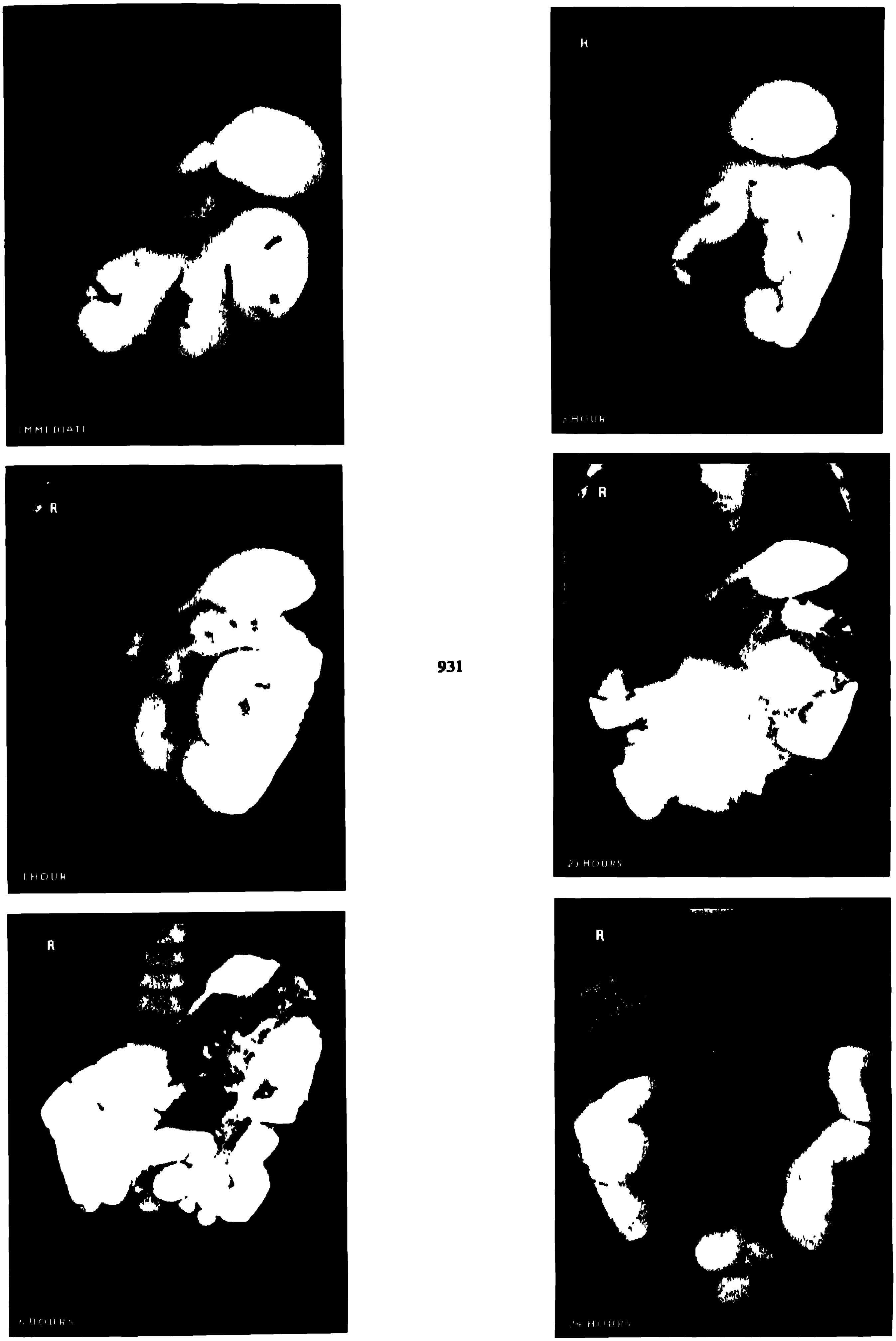
POSTERO-ANTERIOR

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	32	19	30″	Ilford	Tungstate	
85	40	25	30″	Ilford	Tungstate	Potter-Bucky
85	32	19	30″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 17 × 14 in. or 15 × 12 in.

For the oblique position the exposure is increased by 25 per cent.



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Children

YOUNG BABIES

It is necessary to ascertain the quantity of food the baby is normally taking and the intervals and times at which it is taken, so that the opaque meal may replace one of the child's ordinary feeds, the X-ray examination being arranged to commence at one of the child's normal feeding times.

Up to one ounce of bismuth carbonate is mixed with the usual quantity of food and given in a feeding bottle. For breast-fed babies the necessary quantity of milk is obtained from the mother by self expression or by applying a breast pump, the bismuth being added and the meal given in a feeding bottle.

The stomach may be screened by the radiologist, but a series of films is frequently taken without this preliminary.

In babies and infants the duodenal cap is often hidden by the pylorus, and right anterior oblique and lateral positions may therefore be necessary to show the cap and length of the pyloric canal.

The exposure factors are adjusted to allow for a short exposure technique, and the tube is centred to the middle of the film before the child is so placed, in the prone position, that the whole of the abdomen from the diaphragm to the symphysis pubis may be shown.

Films are usually taken immediately, at fifteen minutes, thirty minutes, one hour, and then hourly up to four hours, or until such time as the stomach is empty. To include the colon, films may be taken at six hours, twelve hours, twenty-four hours, and forty-eight hours, as required. Reference should be made to a selection from a series of radiographs (931) taken of a baby aged 4½ months.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	15		30″	Ilford	Tungstate	

Cone or diaphragm to size of film, 10×8 in.

In dealing with children who need to be fed by spoon the bismuth carbonate may be mixed with bread and milk or milk pudding, or a small quantity of the ordinary barium meal, suitably flavoured, may be given.

With older children who are able to feed themselves, from 6 ounces to 10 ounces of the routine barium meal may be given.

Following the meal and screen examination a suitable series of films is taken.

In giving a barium enema it may be necessary to strap young children on to a board to enable the catheter to be retained in position and for the general position to be maintained for screening and the taking of films. On the filling of the colon the catheter may be removed and the buttocks strapped together with adhesive tape to prevent evacuation of the enema while the series of films is being taken. It should be remembered that in cases of Hirschprung's disease the quantity of enema required may be trebled.

COLON—POSTERO-ANTERIOR

The following exposure table refers to the examination of the colon 24 hours to 48 hours after ingestion of a barium meal.

EXPOSURE FACTORS

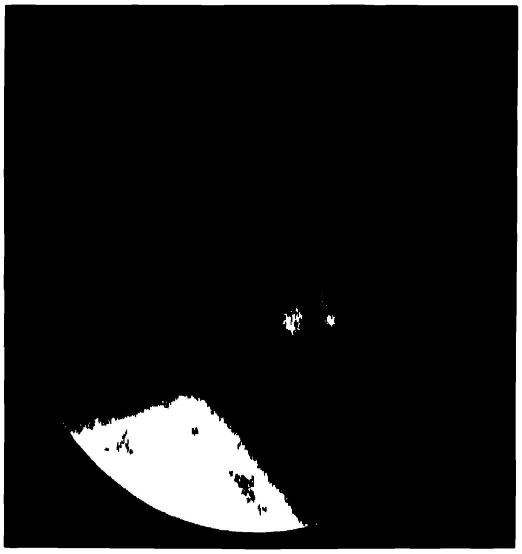
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	32	19	30″	Ilford	Tungstate	
80	40	25	30″	Ilford	Tungstate	Potter-Bucky
80	32	19	30″	Ilford	Fluorazure	Potter-Bucky

Cone or diaphragm to size of film, 15×12 in. or 17×14 in.

SECTION 23

Abdomen

932



933

SECTION 23

ABDOMEN

General views of the abdomen are frequently required as a preliminary to a specialised examination, and should be considered as an important part of the complete investigation. The whole of the abdomen, from diaphragm to symphysis pubis, may be included on a 17 inch by 14 inch film exposed at an anode film distance of from 36 inches to 48 inches, and may be taken with the patient in either the prone or the supine position—preferably the former.

Careful preparation is required, freedom of the colon from both fæcal and gas shadows being essential.

The exposure factors should be adjusted to produce good soft tissue differentiation, the exposure being made on expiration, with an additional film on inspiration as required.

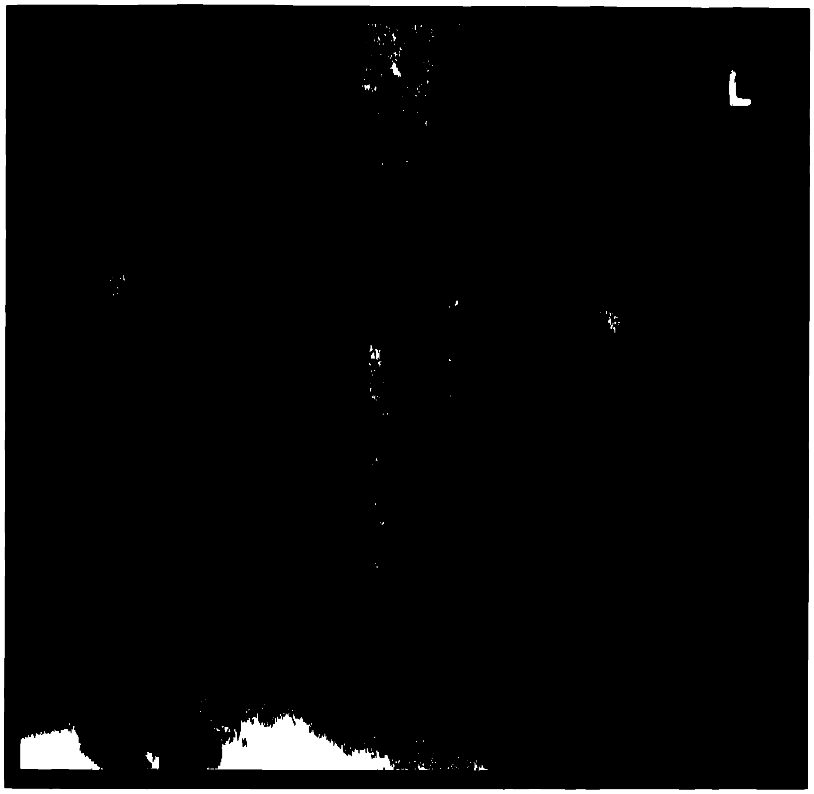
Postero-Anterior EXPOSURE FACTORS

kVp	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	100	60	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 15 12 in or 17 14 in

Illustration **(934)**, taken as a general preliminary film, is unusual in showing several of the important abdominal organs, liver, spleen, gall bladder and kidneys being clearly seen, and it is included here to show the relative positions of these organs. Preparation, however, was unsatisfactory in this case.

The lateral view may also be a part of the general examination of the abdomen, especially when an abnormal condition arises such as calcified glands **(932, 933)**; or following an injection of iodised oil into persisting sinuses, when stereoscopic films may also be taken from both postero-anterior and lateral aspects. The full visualisation of the sinus depends on the technique of injection, it being essential that films should be exposed while pressure on the syringe is maintained **(935, 935a)**. Should there be a pus pocket, however, its extent may be shown by moving the patient into the several necessary positions and exposing further films.



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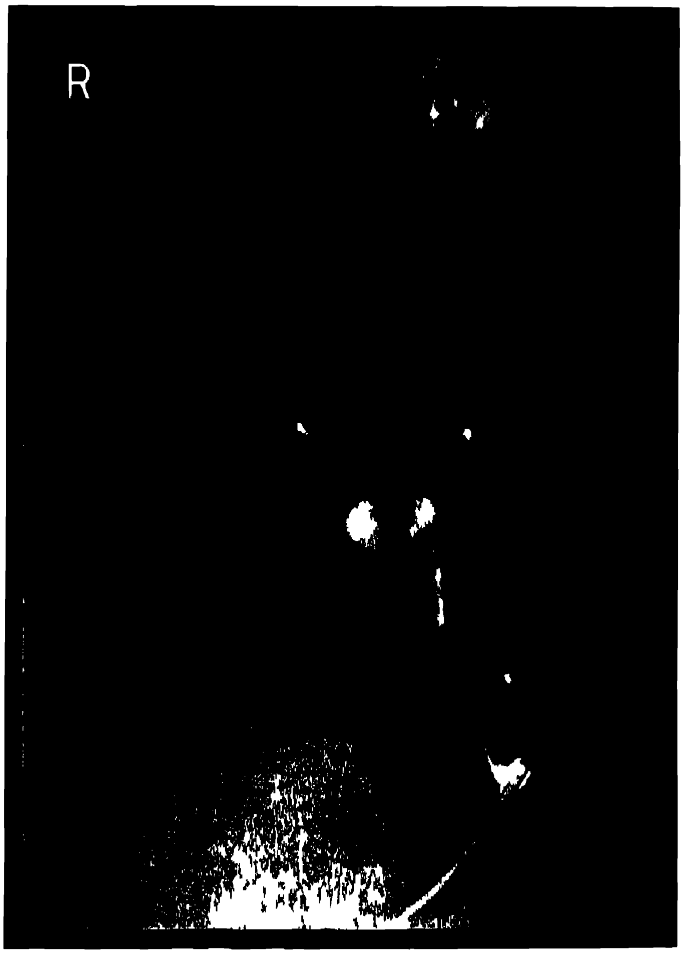
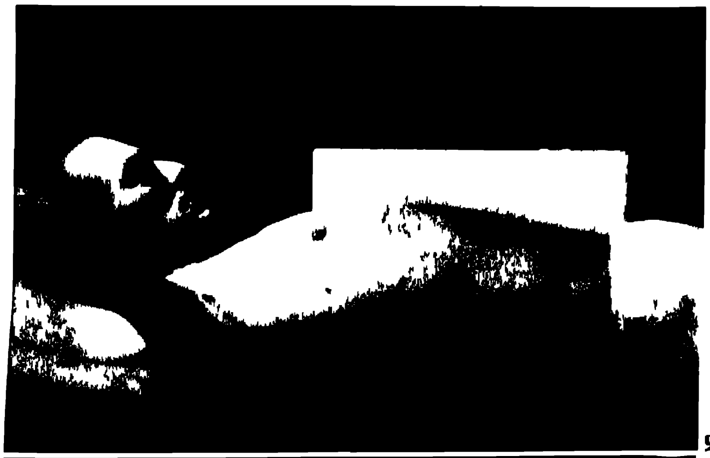
935



935a



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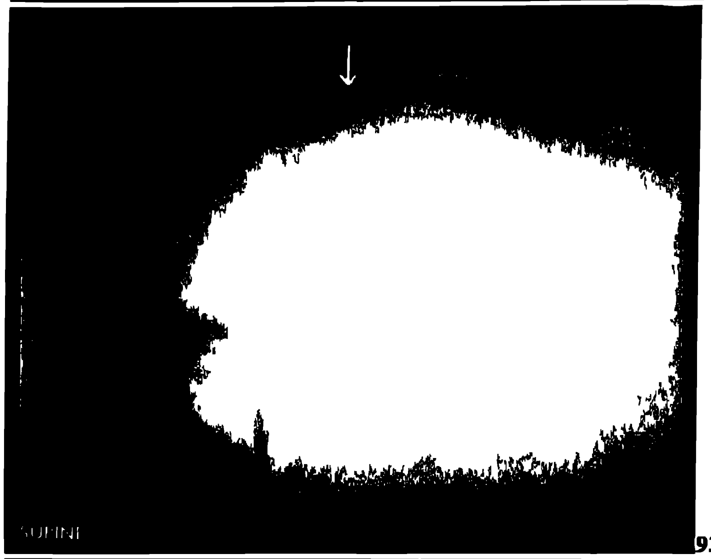

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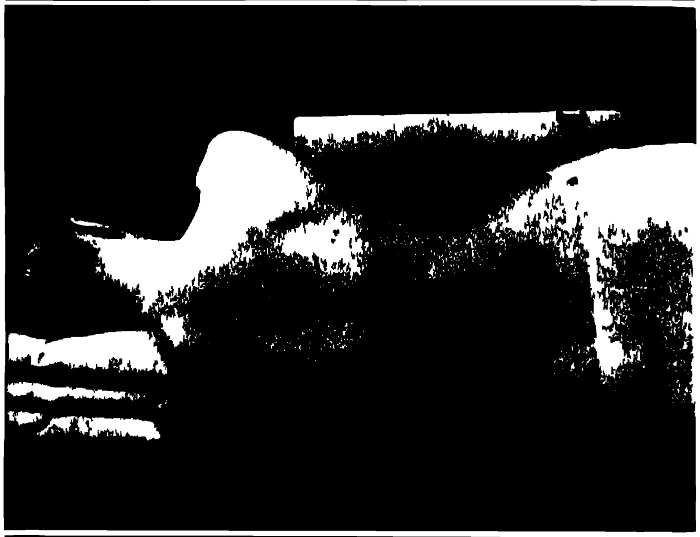


937

937a

Abdomen

Lateral	EXPOSURE FACTORS					
	mA Secs					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
85	148	90	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 15 × 12 in or 17 × 14 in

The abdomen may also be radiographed from both postero-anterior and lateral aspects to show the abdominal aorta, or for hydatid cyst and other abnormal conditions (938, 939).

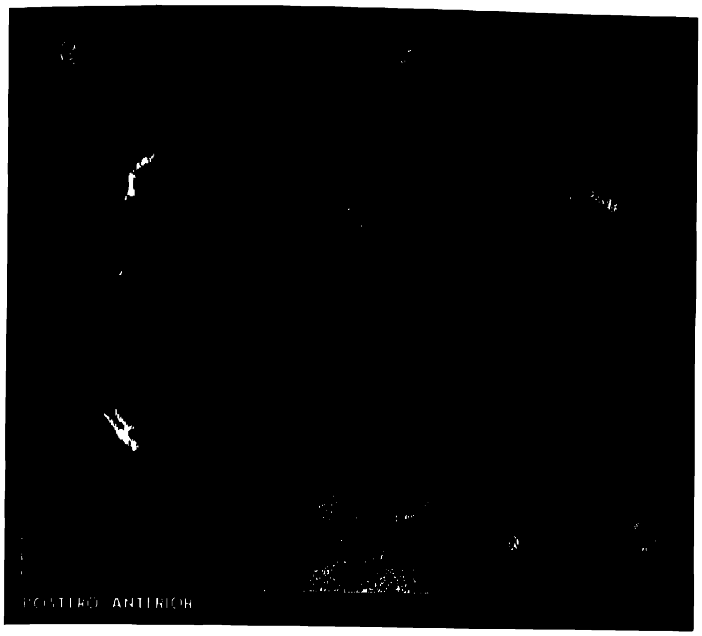
The abdominal aorta is shown best in the lateral view, it being situated approximately half an inch forward from the anterior margins of the bodies of the lumbar vertebræ

Air is sometimes introduced into the peritoneal cavity for the purpose of showing the organs in relief against the artificial contrast of the air-filled background This process is termed "artificial pneumoperitoneum," for which a special injection technique is employed In positioning the patient following the injection it should be appreciated that the air will rise to that part of the abdomen that is uppermost, according to the patient's position Prone and supine (936) positions will show posterior and anterior parts of the abdomen, respectively, films being taken from antero-posterior, postero-anterior and lateral aspects, the last with the film supported vertically against the lateral aspect of the abdomen, (936, 936a), the tube being used horizontally The patient may also be turned on to right and left sides in turn, again using the horizontal tube projection (937) Erect or sitting positions applied as suitable show the upper air level under the dome of the diaphragm (937a)

For the examination of the pelvic organs the pelvis must be raised well above the level of the trunk.

The technique for *artificial* pneumoperitoneum applies also in the case of *spontaneous* pneumoperitoneum due to perforation of the hollow viscus, this latter condition requiring demonstration in the ward to obviate any unnecessary movement of the patient

The exposure factors quoted in this section apply to an adult subject of 157 pounds weight, having a height of 5 feet 8½ inches and, at the second lumbar level, an antero-posterior thickness of 9 inches and a lateral thickness of 10¾ inches.



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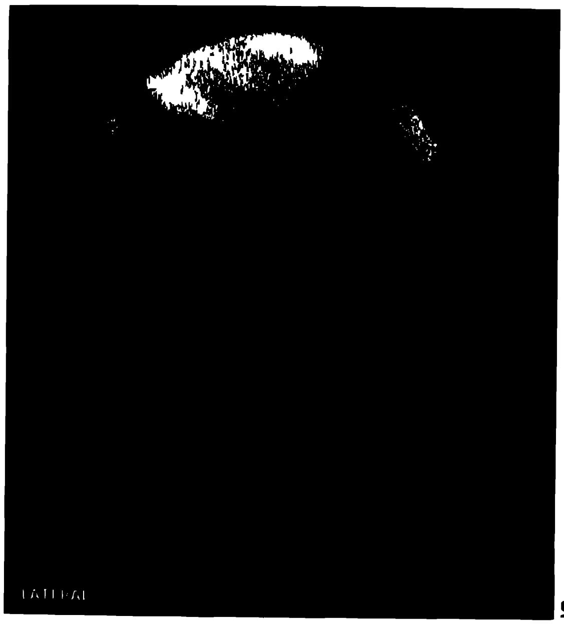


939

939a

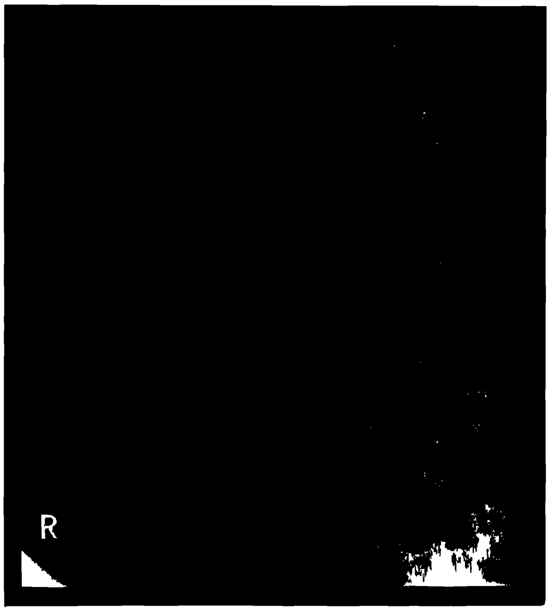
Abdomen

Liver and Diaphragm

The liver is shown in all radiographs of the abdomen and is frequently the subject of special X-ray investigation. Contour variations are most satisfactorily shown: these may be due to enlargement downward, or to such abnormalities as show variation in diaphragm movement or outline. Certain tropical diseases may give rise to gross pathological changes in the liver substance, in the radiographic demonstration of which the exposure technique is somewhat critical, especially in the earlier stages of disease, when additional localised views may be necessary **(939b)**.

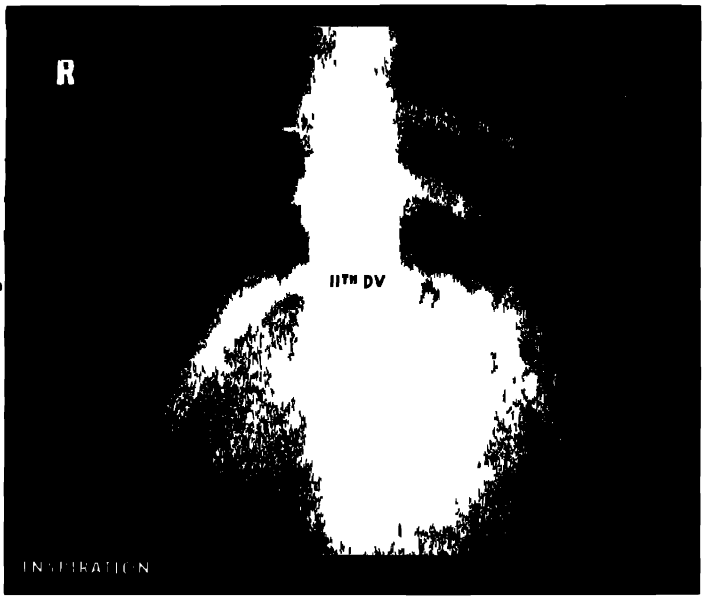
The use of opaque substances to intensify the shadows of the liver and spleen has been introduced, but is not yet established in routine practice. The procedure is known as "hepato-lienography," Thorotrast being used as the opaque medium.

Normally the bulk of the liver is shown as occupying the right side of the abdomen and extending from the dome of the diaphragm to the level of the right lower costal margin **(939a)**. Films should be taken *across* the abdomen and should show the whole of the diaphragm from right to left and include also the iliac crests. Should enlargement of the liver indicate the necessity for a second film, this should be placed, longitudinally, toward the right side of the abdomen so as to include the whole region from the diaphragm to the symphysis pubis, the examination in such a case generally necessitating the use of 17 inch by 14 inch films, a lateral view and an ordinary chest film also being included.



939b

Abdomen: Liver and Diaphragm



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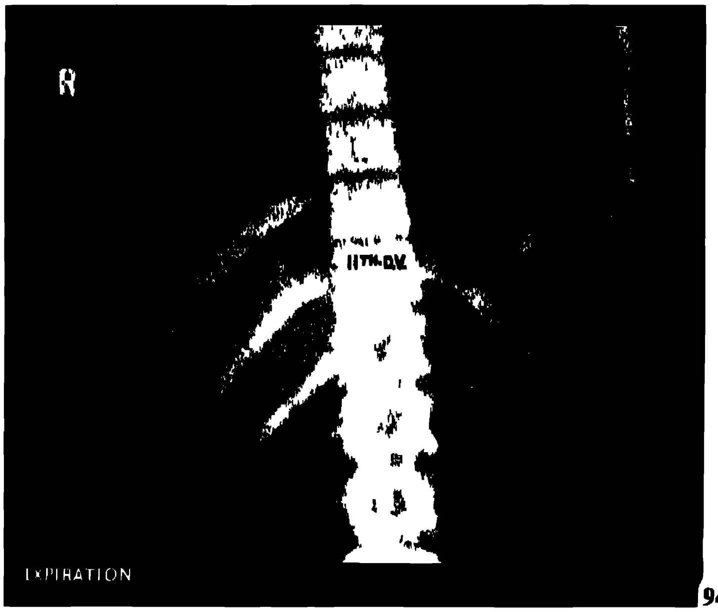


940a

940b

RESPIRATION

Diaphragm *movements* are important and should be investigated by screen examination, or, failing this, films should be taken on inspiration and expiration with the diaphragm centred to the middle of the film, placed across the abdomen, to include the whole of the diaphragm from right to left **(940, 940a)**. The outline of the dome of the diaphragm from the lateral aspect is shown in **(940b)**.

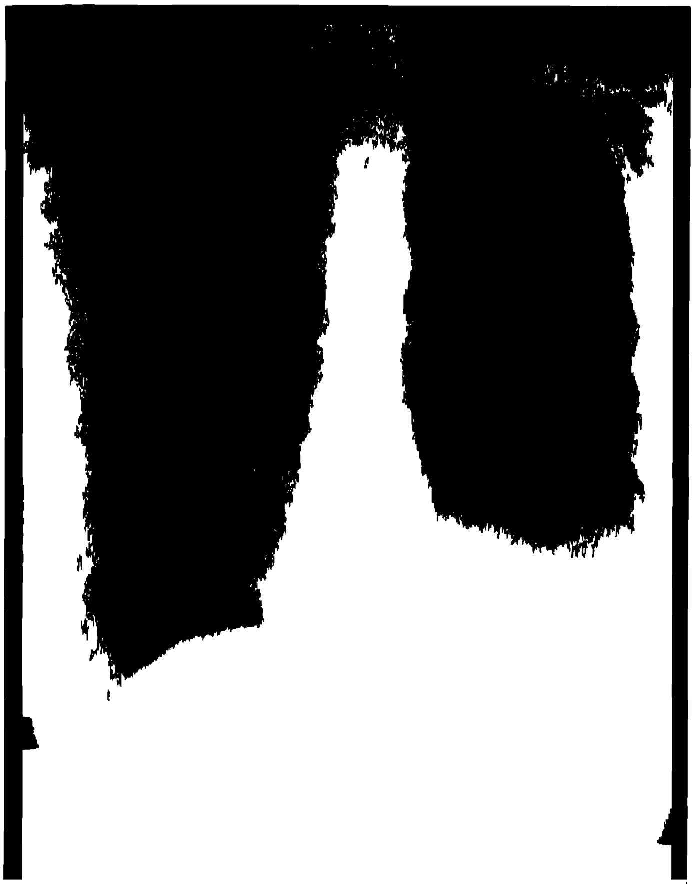
The upper level of the diaphragm, and therefore of the liver, varies not only with respiration but also according to the position assumed by the subject, whether erect or horizontal, and due allowance should be made in placing the films in position.

The ideal procedure is to carry out the entire examination with the patient erect or sitting, so that a gas pocket under the dome of the diaphragm associated with the presence of a sub-phrenic (sub-diaphragmatic) abscess may be readily located. The majority of these patients, however, are too ill to be subjected to erect positioning, and are frequently unfit for any but the supine position, although the prone position is preferable and should be applied whenever the patient is able to turn over on to the abdomen. It is always necessary to deal with these patients as expeditiously as possible.

Films should be exposed with the aid of the Potter-Bucky diaphragm and intensifying screens, and every effort made, by varying the kilovoltage, to locate tissue changes in the liver.

A condition of diaphragmatic hernia or of eventration of diaphragm requires an investigation similar to that applied to diaphragm movements and contour, and may be followed by an examination of the gastro-intestinal tract.

(941, 942, 943)



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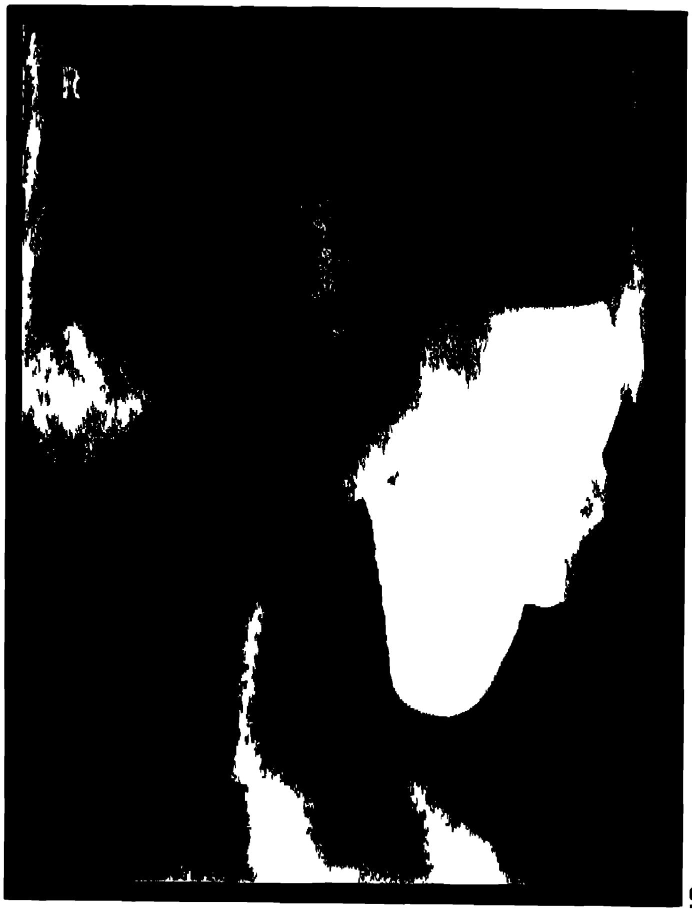

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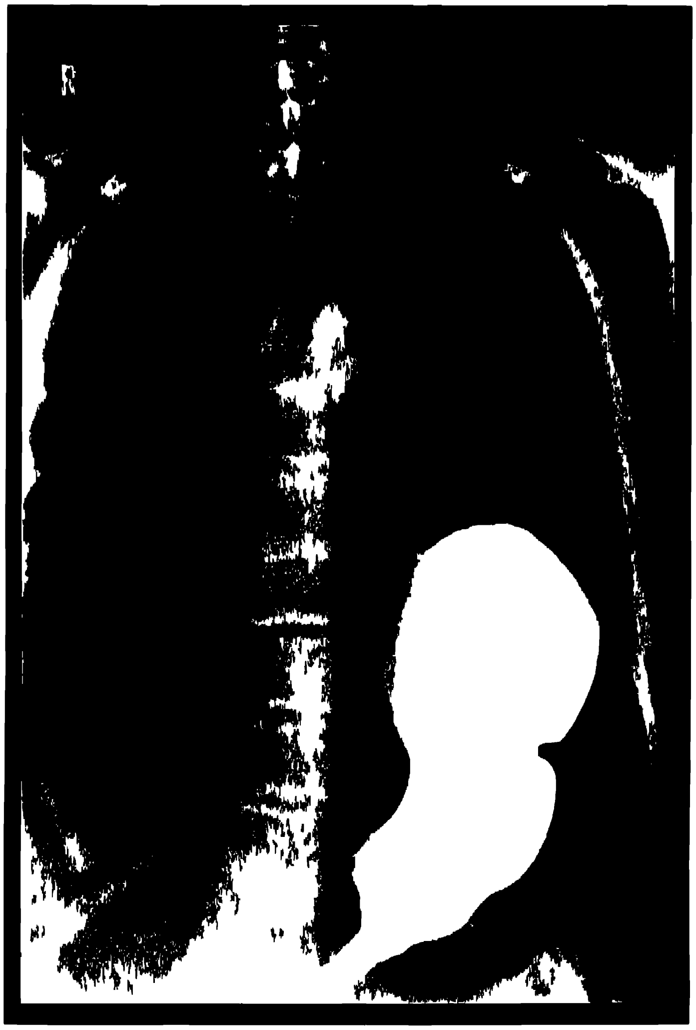


943

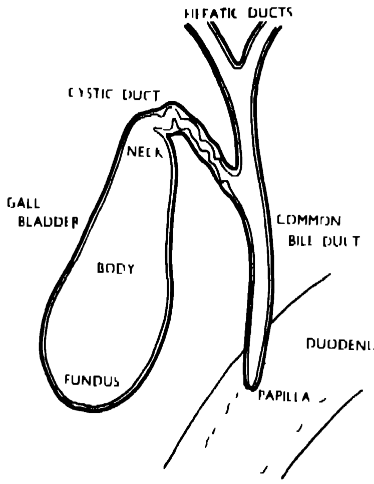
SECTION 24

Gall Bladder

GALL BLADDER

The gall bladder, a hollow, pear-shaped organ consisting of neck, body and fundus, is situated on the under side of the right lobe of the liver, and normally is from 7 centimetres to 10 centimetres in length, 3 centimetres in width at the fundus, and has a capacity of from 30 cubic centimetres to 50 cubic centimetres.

Its function is to act as a reservoir for the concentration of the bile which is secreted by the liver and which flows from the liver to the gall bladder by the hepatic and cystic ducts. During digestion the bile leaves the gall bladder and, passing back through the cystic duct and down the common bile duct, it enters the second part of the duodenum. The common bile duct is joined by the pancreatic duct at or near its opening into the duodenum on a papilla in the mucous membrane **(944)**.



944

VARYING POSITION AND SHAPE

The apparent shape of the gall bladder and its position on the right side of the abdomen varies considerably according to subject type, as discussed in Section 17. Radiographically it appears to vary from the typical pear shape to a spherical form. It may be found at any level between the eleventh rib and the first sacral segment; from side to side it may appear anywhere between the mid-line and lateral wall of the abdomen; from front to back it may be close to the anterior margins of the lumbar bodies, or well forward against the anterior abdominal wall; and from the same aspect the angle of its longitudinal axis may vary from the vertical to the horizontal.

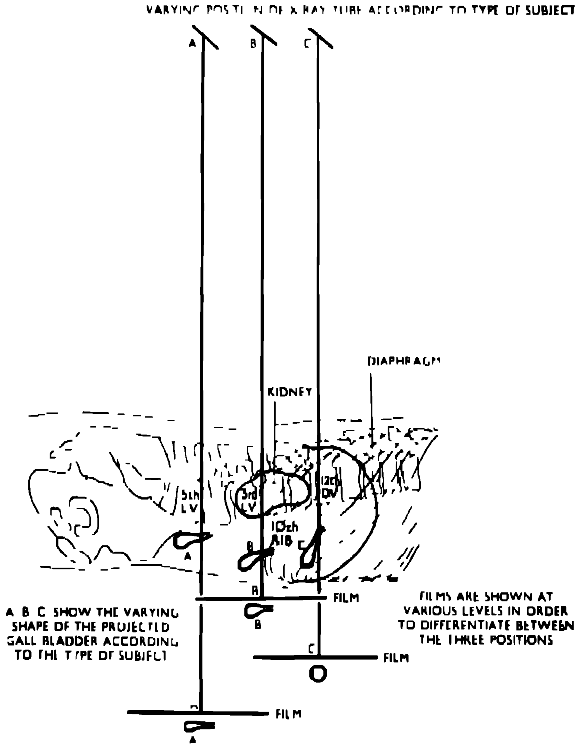
In addition to the variation in position peculiar to the type or habitus of the subject, the gall bladder suffers some displacement with the change of posture of the subject from prone to supine, erect or lateral. Furthermore, during inspiration it moves downward and toward the mid-line. The serial radiograph **(946)** shows the varying position of the gall bladder, rendered visible by the introduction of an opaque medium, at different stages of respiration, the arrows indicating the same bone level in each view.

Advantage is taken of these controllable variations when it is necessary to differentiate the location of confusing shadows occurring, possibly, within overshadowing structures, such as, for example, the right kidney.

The radiographer should be able to anticipate the approximate position of the gall bladder in the various types of subject. In persons of average physique it is shown as a pear-shaped body opposite the second to third lumbar vertebræ, approximately 3 inches from the spinous processes, and toward the right side of the abdomen [B and B^1 in illustration **(945)**].

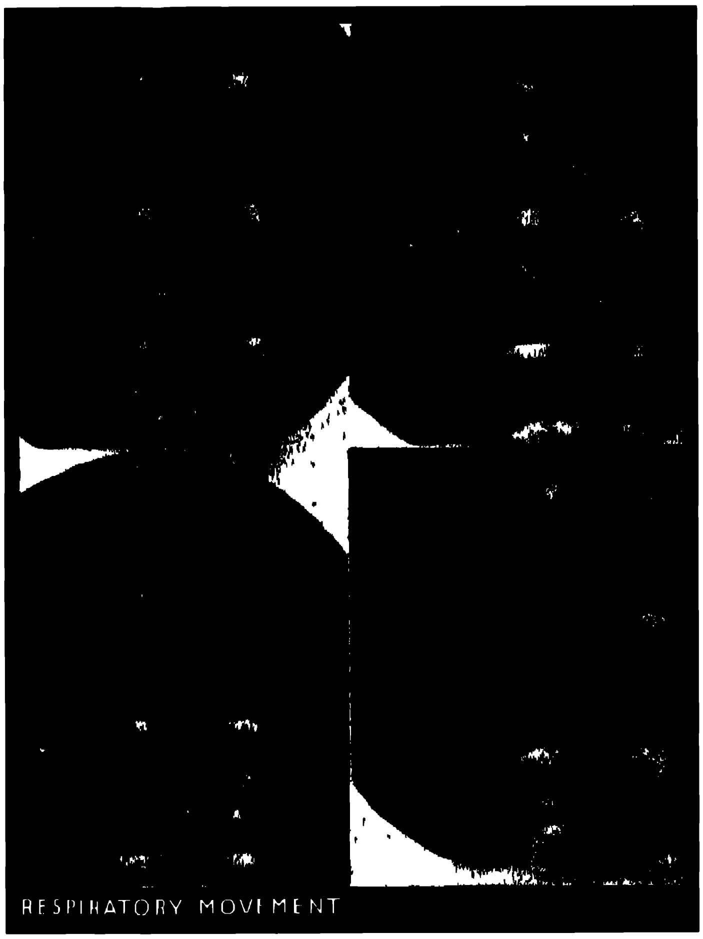
In larger subjects the gall bladder, owing to its almost horizontal position, may appear radiographically as a circular body, the diameter corresponding to the diameter of the fundus as this pear-shaped organ is viewed along its longitudinal axis [C and C^1 in illustration **(945)**].

In subjects of poor physique the gall bladder appears to be elongated, is generally at a lower level and nearer the mid-line, and may, in fact, partially overshadow the fourth and fifth lumbar vertebræ [A and A^1 in **(945)**].



945

The longitudinal sectional diagram **(945)** shows three positions of the gall bladder as seen from the lateral aspect.



946

947

Gall Bladder

SHADOW DIFFERENTIATION

Occasionally, in a superlatively good soft-tissue detail film the outline of the normal gall bladder may be seen, but it is a fortuitous occurrence. If, however, the gall bladder contains an accumulation of X-ray opaque stones its position becomes clearly visible.

Gall stones, or calculi, may vary in size, number, opacity and location: if they are not packed too closely together they may be free to move about within the gall bladder; or they may find their way out of the gall bladder and may block either the cystic duct, or the common bile duct, or both. There may be one large stone, or several large ones, or many small stones; some may be wholly opaque, and others may have an opaque coating but be transparent in the centre and thus give an annular image. One type of gall stone is not X-ray opaque: composed of cholesterin, it casts no shadow, and can therefore only be demonstrated when surrounded by an opaque medium, or "dye," the stone or stones then appearing as relatively clear areas within the surrounding shadow of the opaque medium. **(949a, 950, 951, 952, 953)**

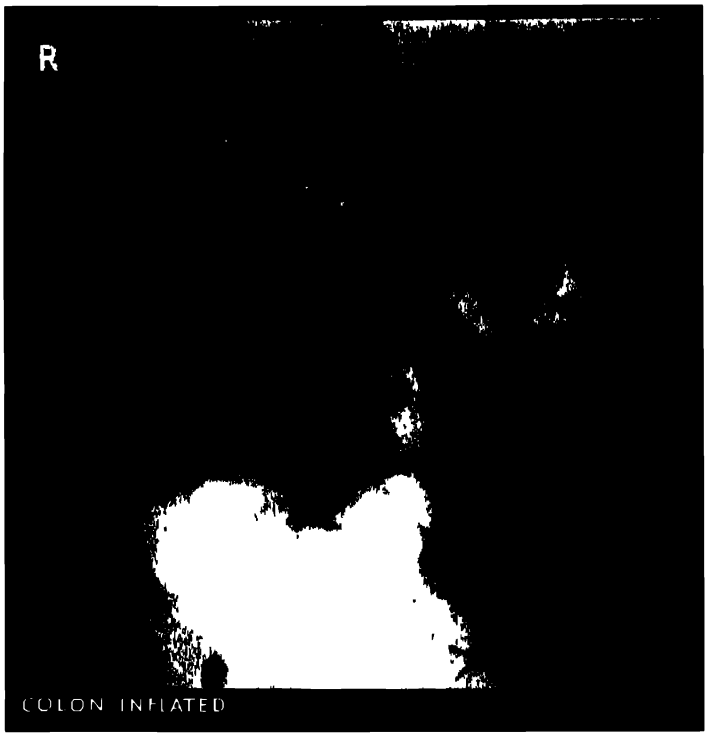
The special technique in which the opaque substance is administered is termed cholecystography, the medium used, sodium tetraiodophenolphthalein, being obtainable under various trade names—Opacol, Shadocol, Stipolac, to name some— for administration by the mouth: the dye is also procurable, in sterile ampoules, for intravenous injection. The medium is peculiar in that it is excreted and concentrated with the bile, which is rendered opaque, the normal gall bladder becoming visible as a pear-shaped shadow.

If the concentration of the dye in the gall bladder is adequate, then not only the size, shape, and position of the gall bladder will be shown, but the presence or absence of non-opaque stones may be demonstrated; and from films taken at intervals, the rate of concentration of the dye and of the emptying of the gall bladder may be estimated.

In certain conditions no shadow of the gall bladder may be obtained, or it may be too faint to be of diagnostic value. Failure to secure an adequate image, however, may have its cause in some fault in the preparation of the patient or in technique, and in this examination the collaboration between patient and X-ray department—particularly as to the instructions given to the patient and to the manner of their observance—which is so desirable at all times, is of great importance.

Cholecystography should always be preceded by the taking of the preliminary film, which serves to show any gross abnormality and which may indicate the line of procedure—with or without the dye—or may, indeed,

948



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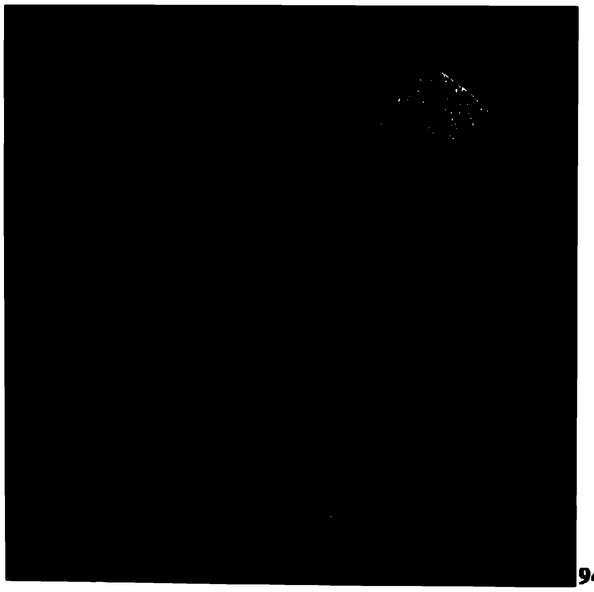


949a

Gall Bladder

SHADOW DIFFERENTIATION *(continued)*

provide all the necessary information to establish a diagnosis and so terminate the examination.

Gas shadows in the colon, which are a frequent cause of difficulty in cholecystography **(947)**, may be obviated by an injection of Pitressin or some other gas eliminator, given one hour before the films are taken, and may also be avoided by the patient taking charcoal biscuits 2-hourly during the preceding day. Serial films taken at different degrees of inspiration and expiration are very helpful when colonic and small intestinal gas shadows overlie the shadow of the dye in the gall bladder.

Illustration **(947)** shows gas shadows in the colon obscuring the gall bladder, although other illustrations show the gall bladder above the level of the colon, whether the latter is deflated **(948)**, or inflated **(949)**.

PREPARATION

Preparation of the patient is important. Freedom of the large bowel from gas and fæcal matter is essential, and, although there are variations from one department to another, it is usual for the patient to be given an aperient, such as cascara evacuant, at 24 hours, and again at 12 hours, before the examination. The patient may be allowed to take a light breakfast, or be requested to attend fasting for the preliminary film. Following this, and in the event of cholecystography being found necessary, the patient is given special *written* instructions to be observed during the subsequent 24 hours.

When making the appointment for the preliminary film, the patient should be informed as to the period which will be occupied by the second part of the examination on the following day.

EXPOSURE TECHNIQUE

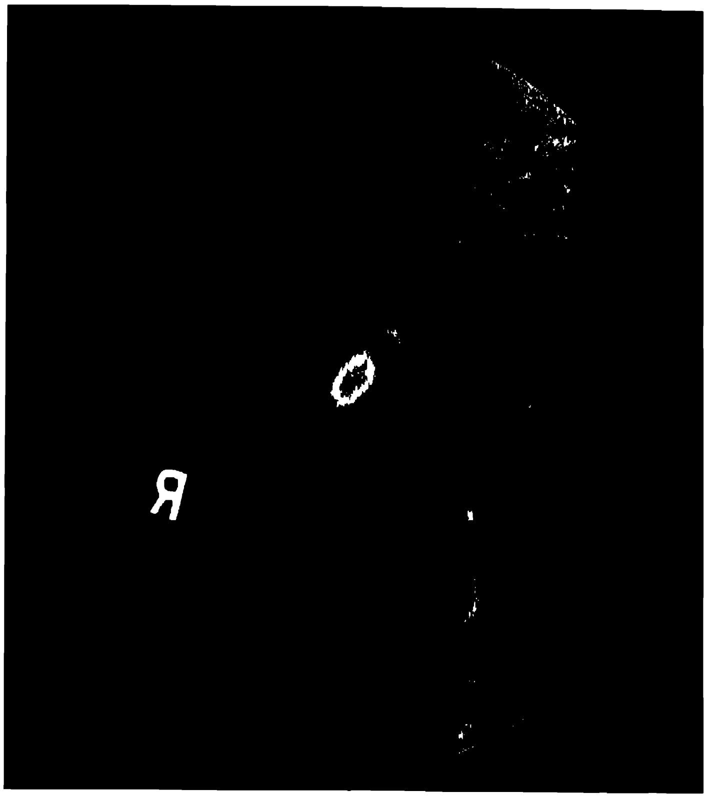
The exposure technique employed should allow for soft tissue differentiation and for a short exposure time, from three-tenths of a second to half a second, during arrested respiration, so that a sharp outline may be obtained. Intensifying screens and the Potter-Bucky diaphragm are employed.

IMMOBILISATION

Immobilisation with the compressor band is advisable, but in large subjects the compression of folds of tissue beneath or over the edges of the band should be avoided as these show as opaque lines on the film.

SUBJECT

The exposure factors quoted in this section apply to an adult subject of weight 146 pounds, having a height of 5 feet $8\frac{1}{2}$ inches and having, at the second lumbar level, an antero-posterior thickness of 8 inches and a lateral thickness of $9\frac{3}{4}$ inches.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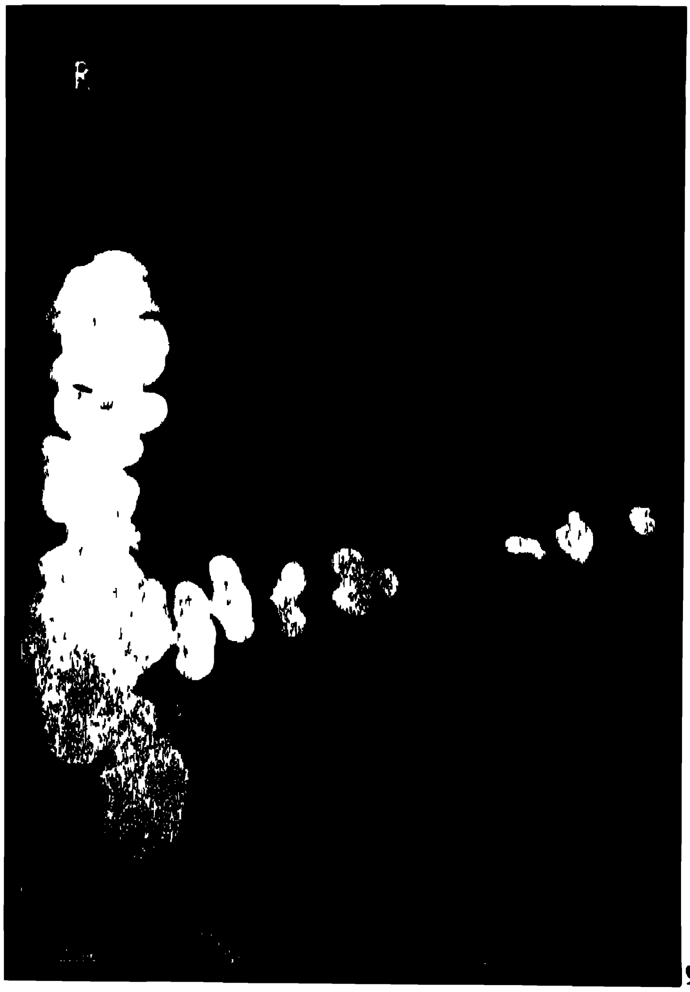
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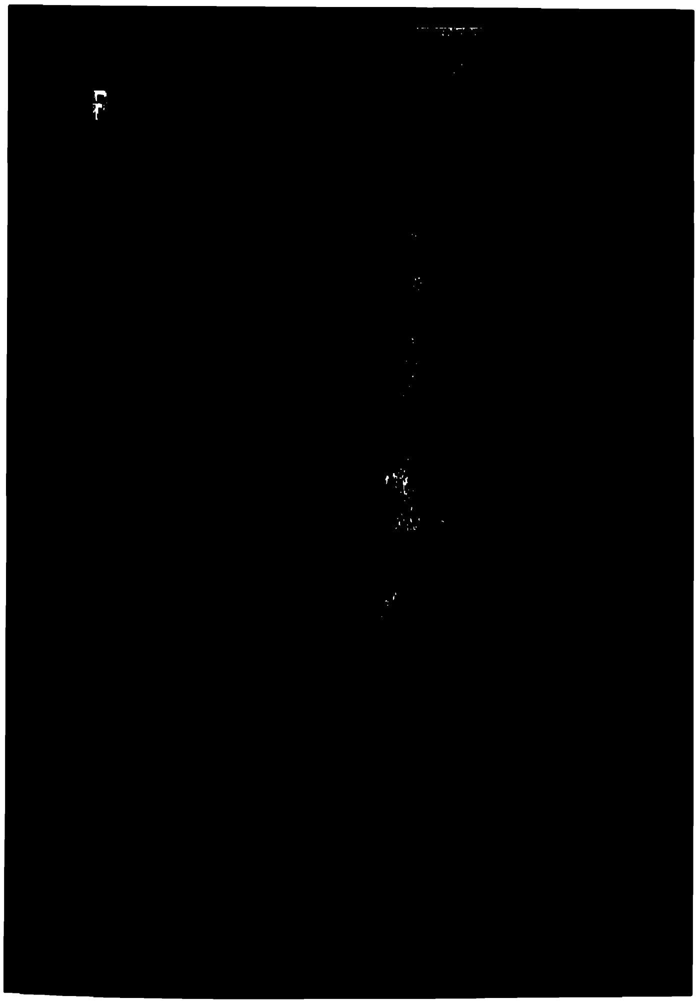
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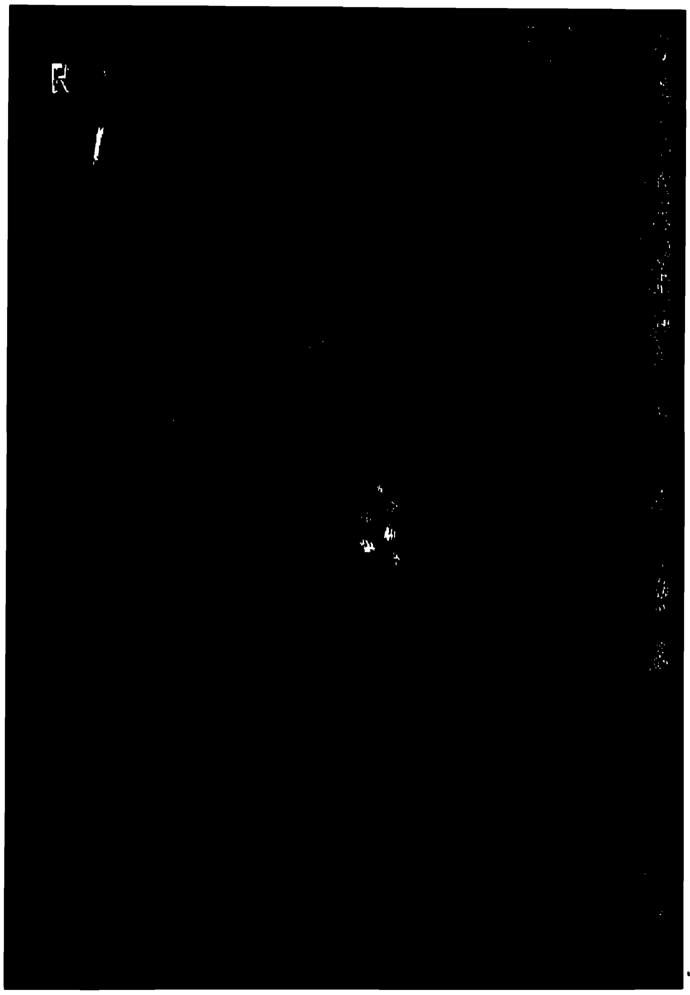
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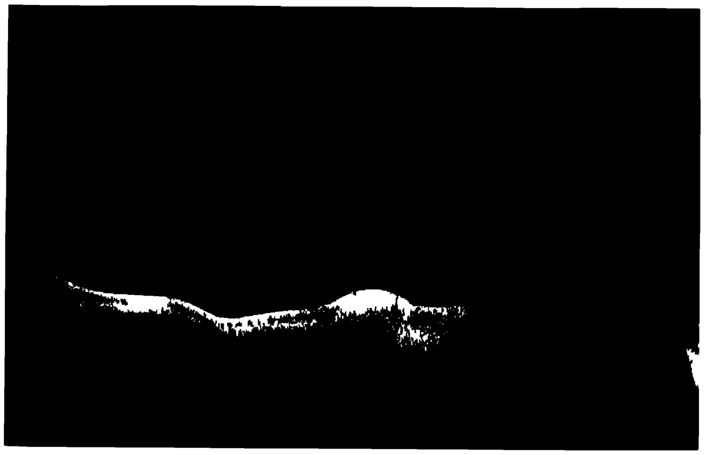

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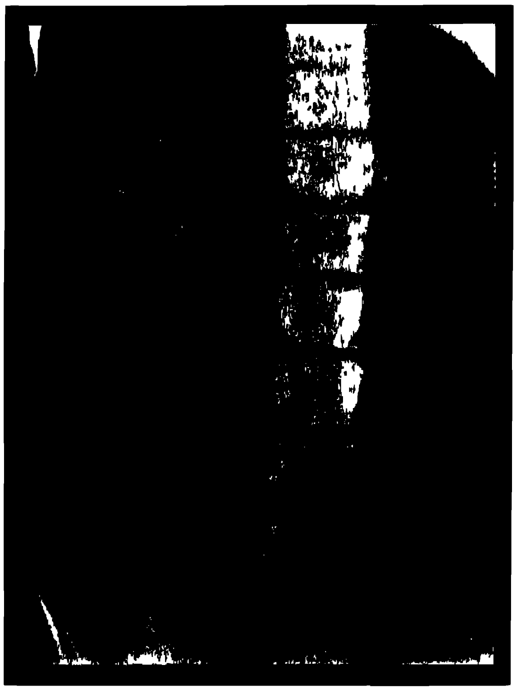

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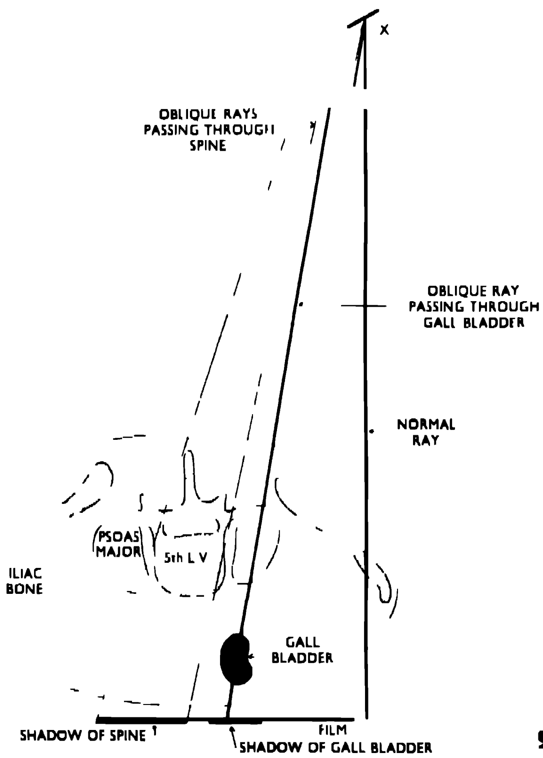


956

Gall Bladder

IDENTIFICATION

Careful marking of films for identification of subject and times of taking after administration of the dye is essential. The phase of arrested respiration should also be noted.

POSTERO-ANTERIOR

The patient is placed in the prone position with the right side of the abdomen to the centre of the Potter-Bucky couch, the flat-topped couch being preferable. When the curved type is in use a wool pad may be placed under the right hip and right upper abdomen to preserve the true postero-anterior position of the patient. The ankles should be raised on a sandbag or allowed to project over the end of the couch to prevent uncomfortable pressure on the toes (**954**). The head is turned to one side, and the arms placed beside the trunk (**957**), or above the head (**954**), or the hands may be clasped high up under the chest (**959**).

The film should be adjusted to include the region from the eleventh rib to the iliac crest in the average subject (**957**), or higher (**959**), or lower (**961**), according to subject type.

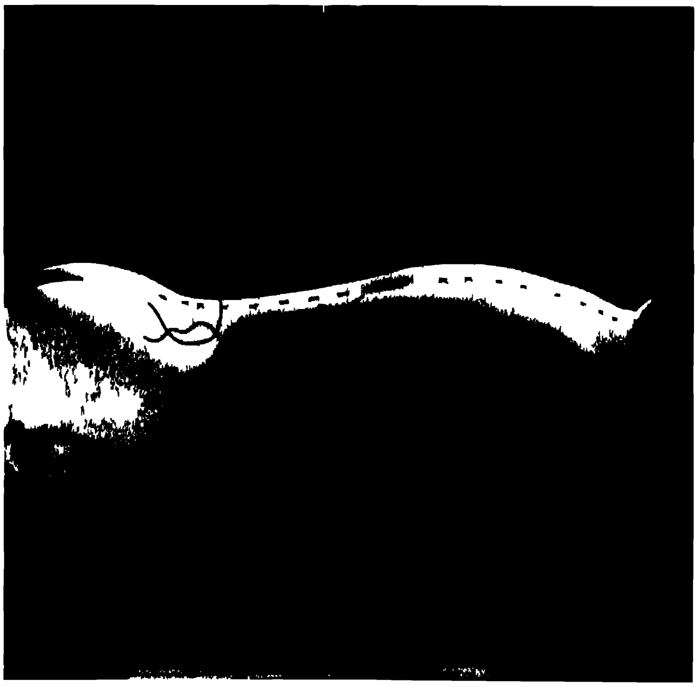
CENTRE, for average subjects, at the level of the second to third lumbar region, 3 inches away from the spinous processes and toward the right side of the abdomen (**954, 955, 957, 958**). For large subjects it may be necessary to adjust the centring point approximately 5 inches to the right of the eleventh or twelfth dorsal vertebra (**959, 960**).

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	*75	*45	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 10 × 8 in.
* Exposure time from [illegible] to [illegible] second.

For small subjects, where the gall bladder may actually overshadow the fourth to fifth lumbar spine (**962**), the centring point should be well away from the spine, and at the level of the iliac crest (**961**). As will be seen in the cross-sectional diagram (**956**), the spine shadow is thus projected away from the gall bladder shadow (**964**). When using a small localising cone for this position the tube should be angled toward the spine.

Exposure technique is adjusted to suit the type of patient, kilovoltage being the variable factor except for extreme types, for whom adjustment in the exposure time may also be necessary.



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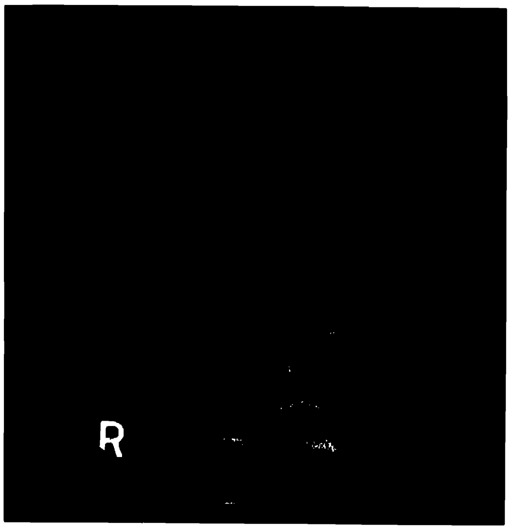

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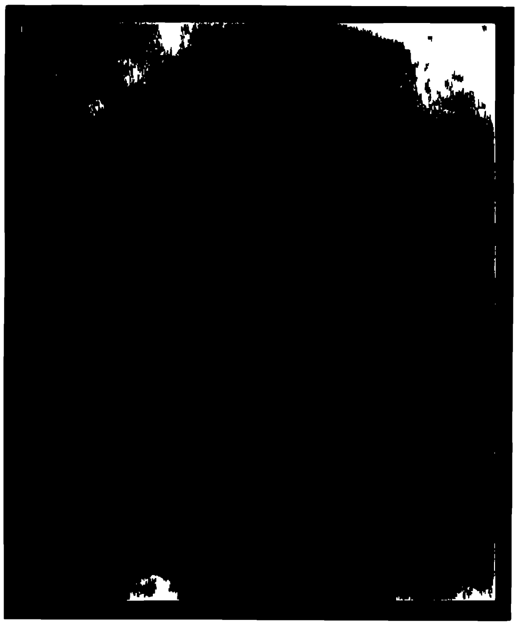

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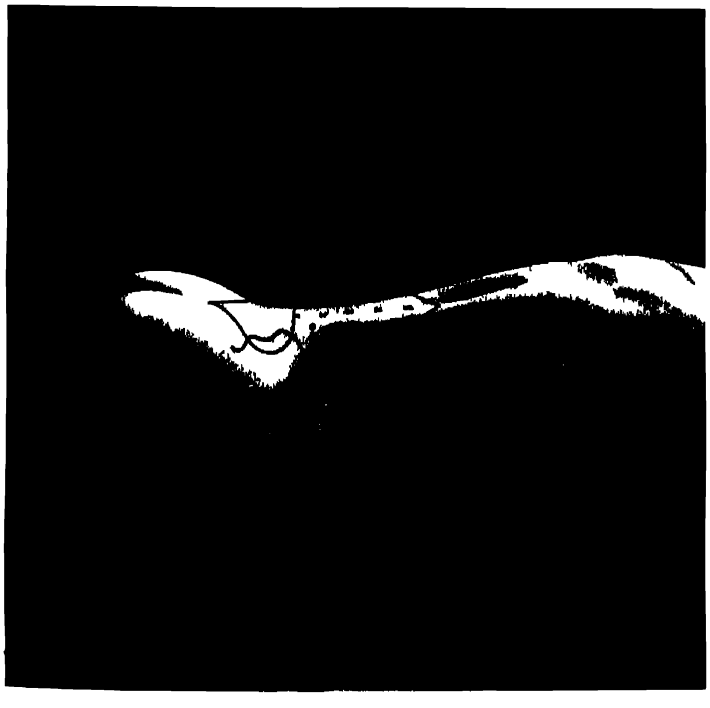
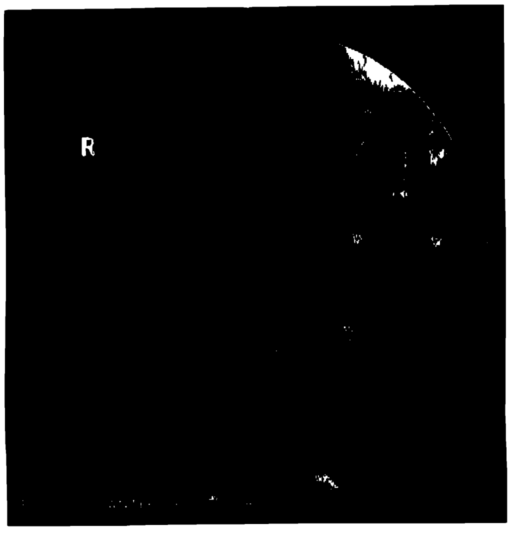


961



962

Gall Bladder

POSTERO-ANTERIOR *(continued)*

The same technique is applied for both preliminary and cholecystography films, with the exception that after having localised the dye-filled gall bladder it is possible to use a small localising cone, when a single small film will suffice for each exposure.

OBLIQUE

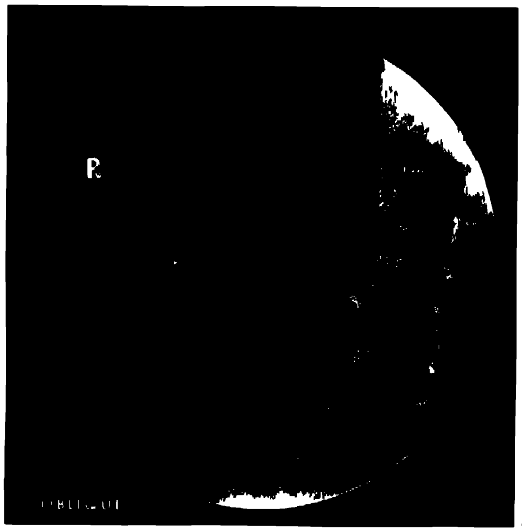
As an alternative to off-centring the tube when the gall bladder overshadows the lower spine the oblique position may be used, the right side of the patient being raised 3 inches to 4 inches away from the couch and supported by wool pads under the hip joint and upper abdomen.

CENTRE over the fourth lumbar vertebra. The effect of this positioning and centring is to separate the shadows of gall bladder and spine, as shown in the cross-sectional diagram **(956)** and the radiograph **(964)**.

For the oblique view an increase of 5 kilovolts is required as compared with that for the postero-anterior view.

It should be noted that radiographs **(962)** and **(964)** were taken of the same subject.

963



964

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	*75	*45	36″	Ilford	Tungstate	Potter-Bucky

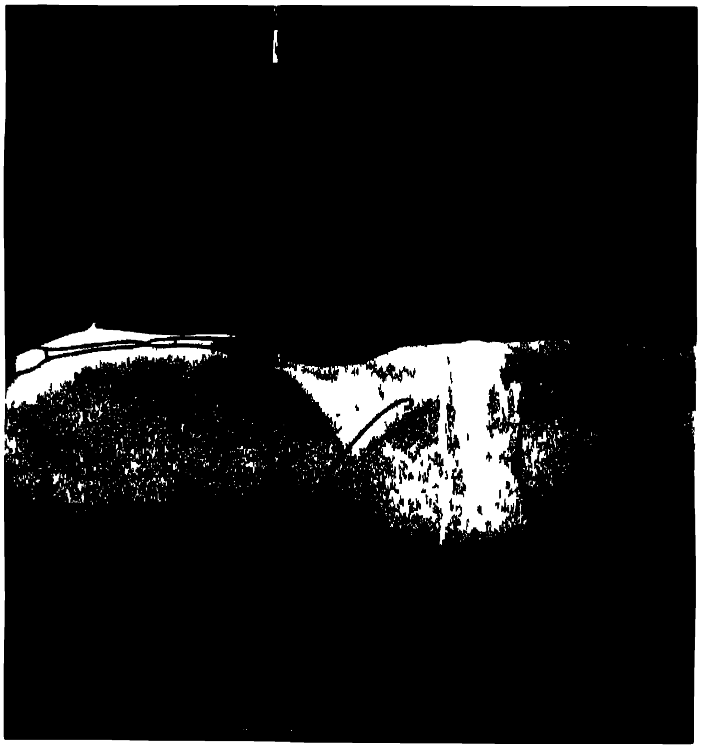
Cone to size of film, 10 × 8 in. or 12 × 10 in.
*Exposure time from [illegible] to [illegible] second.

ANTERO-POSTERIOR

The patient is in the supine position, with the spine to the left of the mid-line of the couch. When the curved-topped couch is used it may be necessary to raise the right side of the trunk on wool pads in order to obtain a true antero-posterior position. For the patient's comfort small sandbags should be placed under knee and ankle joints.

CENTRE for average subjects one inch above the level of the lower costal margin and 3 inches to the right of the mid-line, adjusting the centring point for larger or smaller subjects as previously described **(965, 967)**.

It should be noted that anatomically the gall bladder projects obliquely forward and downward in the abdomen, and therefore when the prone position is assumed its contents collect in the fundus, which is then at the lowest level **(966)**, and free opacities may overshadow each other.



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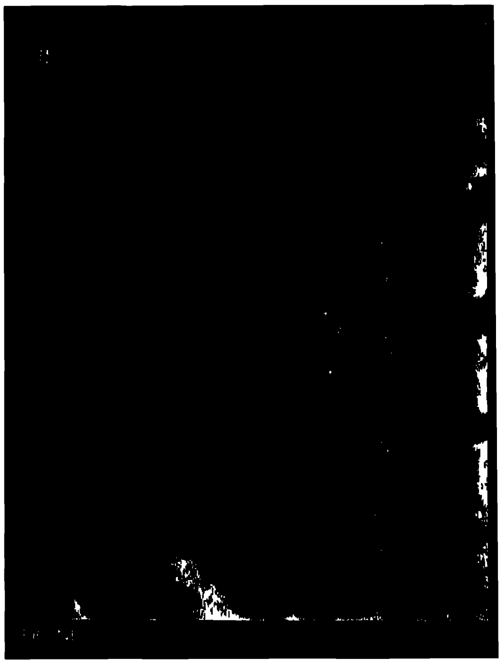
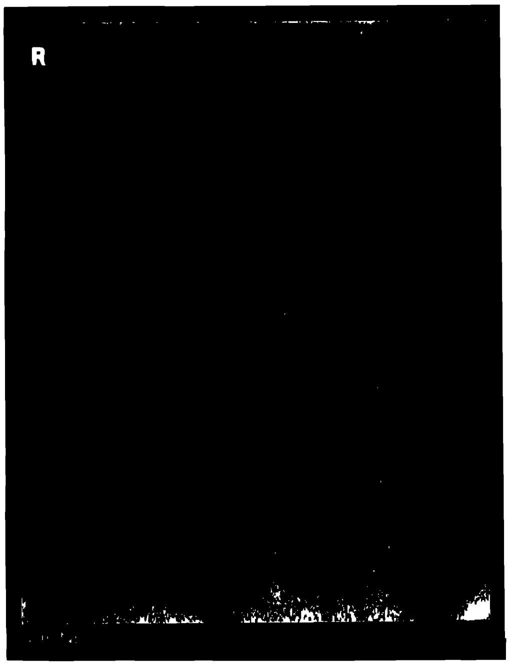
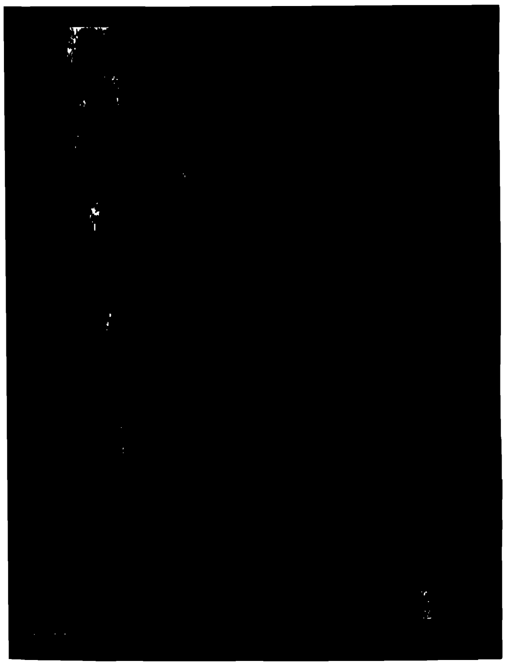




967



968

Gall Bladder

ANTERO-POSTERIOR *(continued)*

When the patient is turned into the supine position these free opacities tend to fall backward toward the cystic duct and are usually shown as separate shadows, being also higher in the abdomen and farther away from the mid-line as shown in radiograph **(967)**, as compared with **(966)** taken in the prone position. These, and also the lateral view **(968)**, show the same subject. Furthermore, on comparing the prone and supine films it will be seen that in the prone position, owing to their closer proximity to the film the gall bladder opacities are more sharply defined, and smaller, than in the film of the supine position, diffusion and enlargement of the film shadows being the result of greater gall bladder-film distance.

The importance of these two positions will be appreciated when there arises any question of differentiating between shadows in the gall bladder and those in other overlying organs and structures. In such cases an additional view, taken on the radiographer's initiative on viewing the preliminary film of the prone position, may resolve any uncertainty.

This view is also important for outlining the ducts with opaque medium for cholecystography **(370)**.

LATERAL

The patient is turned until the right side of the abdomen is in contact with the Potter-Bucky couch, the positioning being similar to that applied for the lateral lumbar spine.

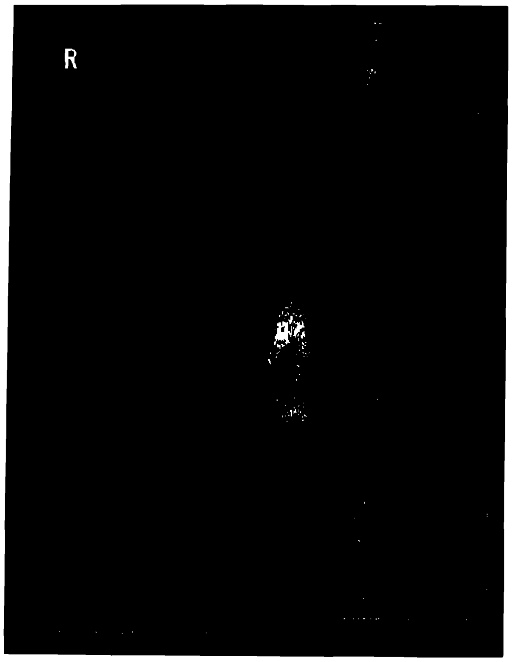
CENTRE according to the position of the gall bladder.

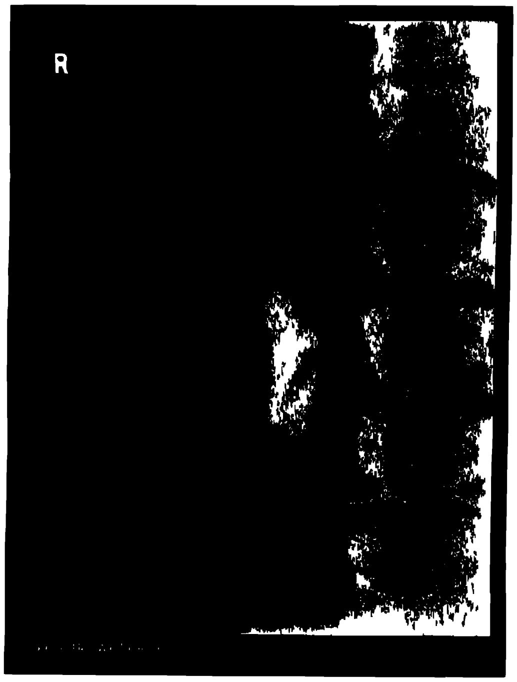
EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	100	60	36″	Ilford	Tungstate	Potter-Bucky

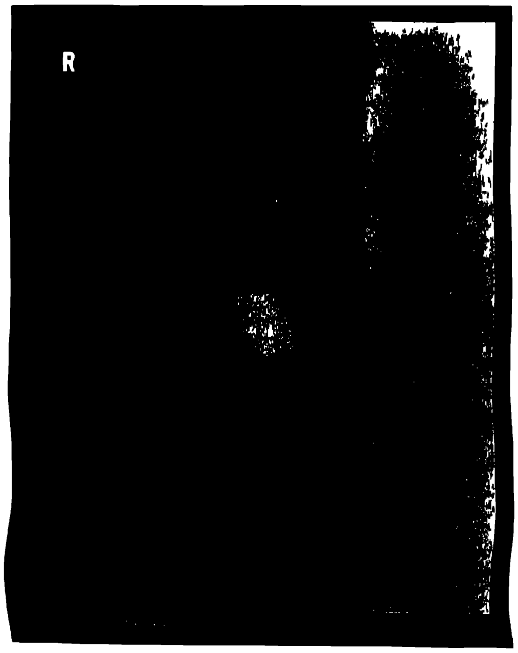
Cone to size of film, 12 × 10 in.

The radiographs **(966, 967)** and **(968)** show the same subject 15 hours after the ingestion of the opaque medium.

Erect positioning may also be adopted from any aspect to show adjacent relationship as compared with the horizontal position.







969

Gall Bladder

Cholecystography

The opaque medium, sodium tetraiodophenolphthalein, usually referred to as T.I.P., or "the dye," is, as previously stated, supplied under various trade names to be given by mouth and for intravenous injection.

BY MOUTH

When the dye is given by mouth the fluid form is used, the giving of powder capsules having been superseded by this method.

The powdered dye is supplied in small bottles, each containing the full dose for an adult subject. The powder is added to half an ordinary tumblerful of water. At first the fluid is pale mauve in colour, but on brisk stirring becomes frothy and milk-like in appearance, when it is ready for the patient to drink. In mixing the dye, the maker's instructions should be closely followed.

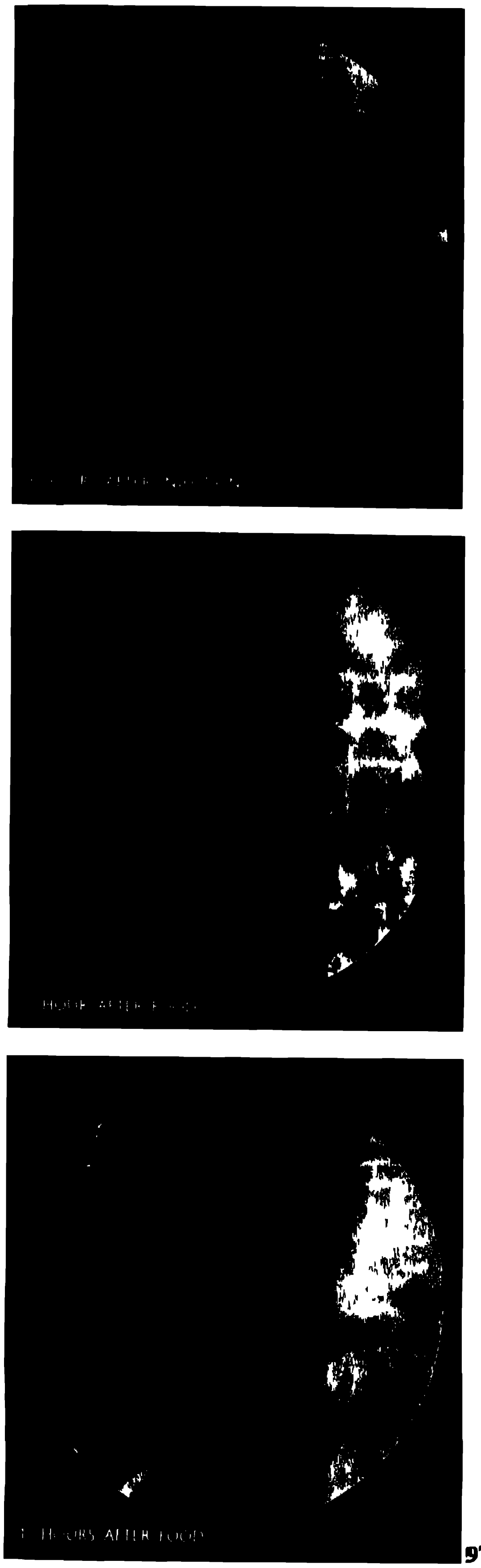
TAKING THE DYE

The dye is usually administered during the evening of the day on which the preliminary film is taken, so that the patient is already prepared with the colon free from gas and fæcal matter: a light diet is maintained, and the last meal, consisting chiefly of cereals and fruit, but *no fats*, is taken at 6 o'clock in the evening. The dye is given three hours later, the time being adjusted to suit the hour at which the individual department is able to arrange the X-ray examination.

The patient is recommended to lie on the right side during the night. Nausea occasionally follows the taking of the dye, but unless vomiting occurs within an hour afterwards the examination should proceed, as a sufficiency of the dye will have been retained to give a satisfactory outline of the gall bladder.

FILM SERIES

The X-ray examination is commenced 12 hours to 15 hours after the taking of the dye, and it should be impressed upon the patient that it is of the utmost importance that the instructions given by the X-ray department concerning this 12-hour to 15-hour interval should be strictly followed. The taking of both fluids and solids is usually suspended during this period. The original technique is, however, frequently modified and the radiologist's instructions should be obtained.



970

FILM SERIES *(continued)*

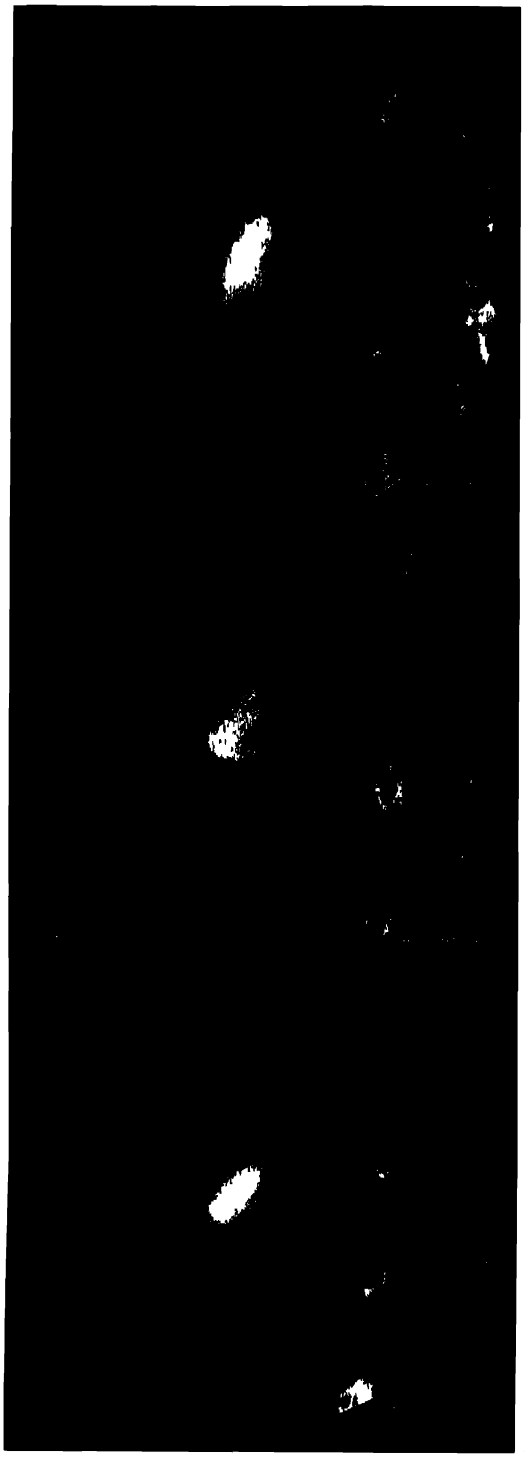
The dye having been given at 9 p.m., the first film is exposed at either 9 a.m. or 12 noon on the following day. In many X-ray departments the 12-hour film is omitted, and when the 15-hour film shows the gall bladder to have filled satisfactorily, it is followed immediately by a meal containing plenty of fat, or better still and more conveniently, by one or two eggs, preferably the yolks only, beaten up in creamy milk, a second film being taken half an hour after the meal; and one hour later a third film is exposed. Serial films may, however, be taken more frequently and may commence 10 minutes after the meal. This part of the X-ray examination is thus completed within a maximum period of two hours, commencing 15 hours after the taking of the dye. The omission of the 12-hour film saves considerable early morning congestion in the X-ray department, and the 15-hour series is usually found to be adequate for the purpose of diagnosis. When the gall bladder fails to fill at 15 hours a second dose of the dye may be given and the radiographic examination continued on the following day. Should any deviation occur in the routine procedure, details should be noted for the information of the radiologist. Errors in following directions should, however, be obviated by carefully worded written instructions to the ward sister in charge of the patient, or to the out-patient concerned. Most X-ray departments maintain a supply of prepared typed or printed instructions.

The two series of illustrations under (**969, 971**) show the appearance of the gall bladder at intervals following the taking of the dye, in fluid form, by mouth.

INTRAVENOUS INJECTION

The sodium tetraiodophenolphthalein is supplied in 30 cubic centimetre sterile ampoules containing 3·5 grammes of the dye. The dye is injected by the surgeon into the vein on the anterior aspect of the elbow. Great care is exercised, as the dye is very toxic, and the slightest trace outside the vein gives rise to severe reaction which may take a considerable time to heal.

The intravenous method is usually applied when the oral method has failed to produce a shadow of the gall bladder, but it may be used also for the initial examination. It is considered to be more reliable than the oral method, but in view of the difficulties of injection it is not commonly used as the routine procedure. The subject is prepared as described earlier, prior to the taking of the preliminary film, which may be exposed immediately before the injection.



971

INTRAVENOUS INJECTION (*continued*)

The first dye film is taken 6 hours after the injection and if a satisfactory shadow of the gall bladder is shown the patient is given a meal containing fat, and further films are exposed half an hour and one hour after the meal. Should the gall bladder fail, however, to show in the 6-hour film, another film is exposed 2 hours later—at 8 hours after the injection—before the meal is given and subsequent films are exposed **(970)**. In certain departments, however, the injection is made during the previous late evening and the first film exposed 10 hours later.

GENERAL

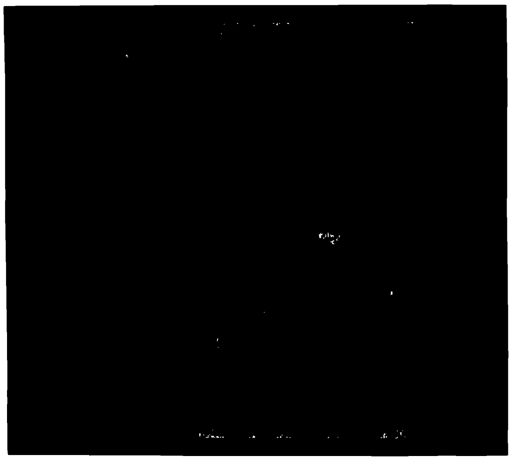
After the shadow of the gall bladder has been located, a small extension cone may be used to cover the area occupied by gall bladder and cystic duct, and smaller films be used for the subsequent exposures.

Two illustrations are included to show the cystic duct, outlined by dye in **(973)**, and blocked by a calculus in **(972)**.

A preliminary screen examination to locate the gall bladder allows the whole examination to be covered economically as regards films, but this method depends largely upon the screen facilities available and also upon the size of the patient as a suitable screen subject. Three exposures are sometimes made on one 17 inch by 7 inch film, but this entails the retaining of the cassette for a single patient until the examination is complete, and is only possible, therefore, in departments where many cassettes are available or few patients treated **(971)**.

CHILDREN

For children two-thirds only of the full quantity of dye, whether taken by the mouth or injected, is given between the ages of 10 years and 14 years, and for children of less than 10 years from one-third to one-half of the full dose.



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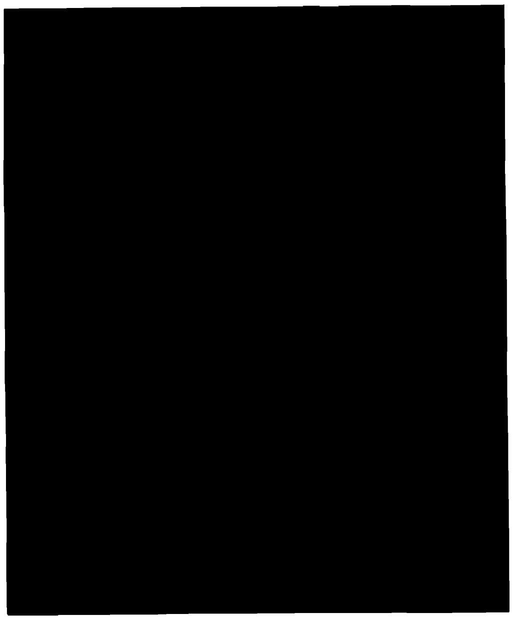

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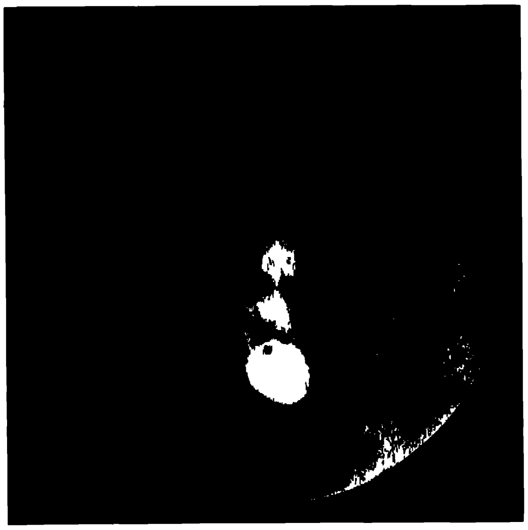

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Gall Bladder

INJECTION OF A BILIARY FISTULA

Sometimes after an operation on the gall bladder the wound does not completely heal, a narrow tract leading from the skin to the gall bladder remaining. An injection of iodised oil into the opening in the skin will show in the radiograph the organ and the size, length and direction of the fistulous tract, pressure being maintained on the syringe during the exposure **(974)**.

The injection is made during the screen examination under carefully controlled conditions, particularly as to the quantity of oil injected. When the injection is made following the removal of the gall bladder, the hepatic ducts and the common bile duct are outlined, and the examination is referred to as cholangiography **(975)**.

GALL BLADDER AND DUODENUM

When the gall bladder is seen to outline satisfactorily or its position has been located by the presence of gall stones, a small barium meal may be given to show the relative positions of gall bladder and duodenum, a screen examination by the radiologist preceding the taking of the films. In certain departments this is regarded as routine procedure.

PATHOLOGICAL SPECIMENS

Radiographs of the gall bladder after its removal are frequently required, and comparison with the shadows shown in the pre-operation films is of interest. Prints of these radiographs are usually required for inclusion in the patient's case notes.

(976, 977)

The following exposure factors are suitable for specimen work.

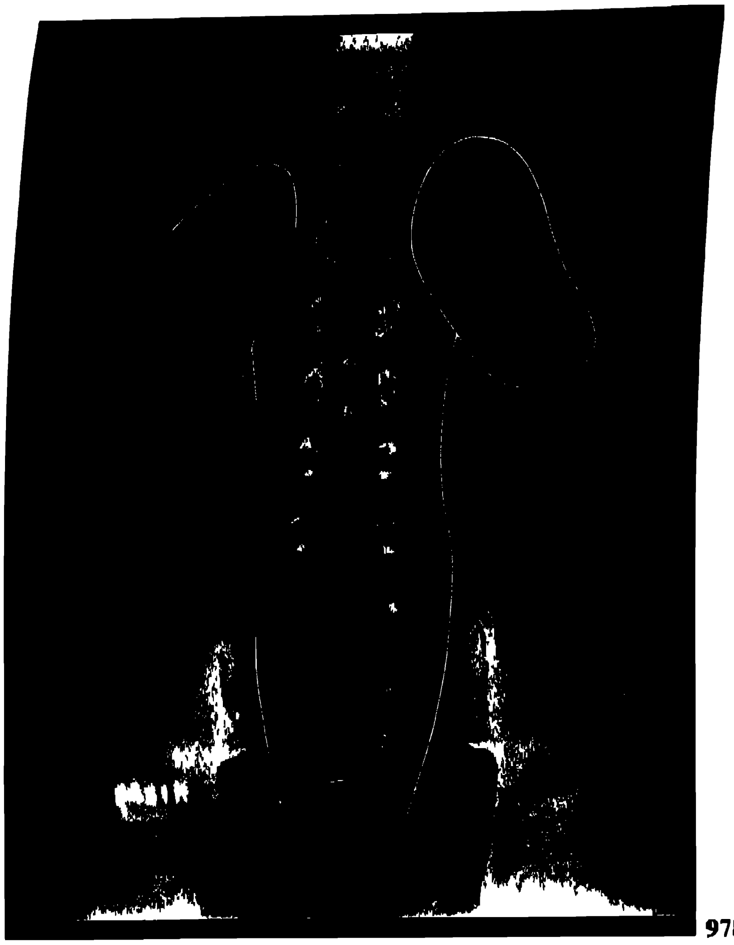
EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
30	132	80	30"	Ilfex	-	—

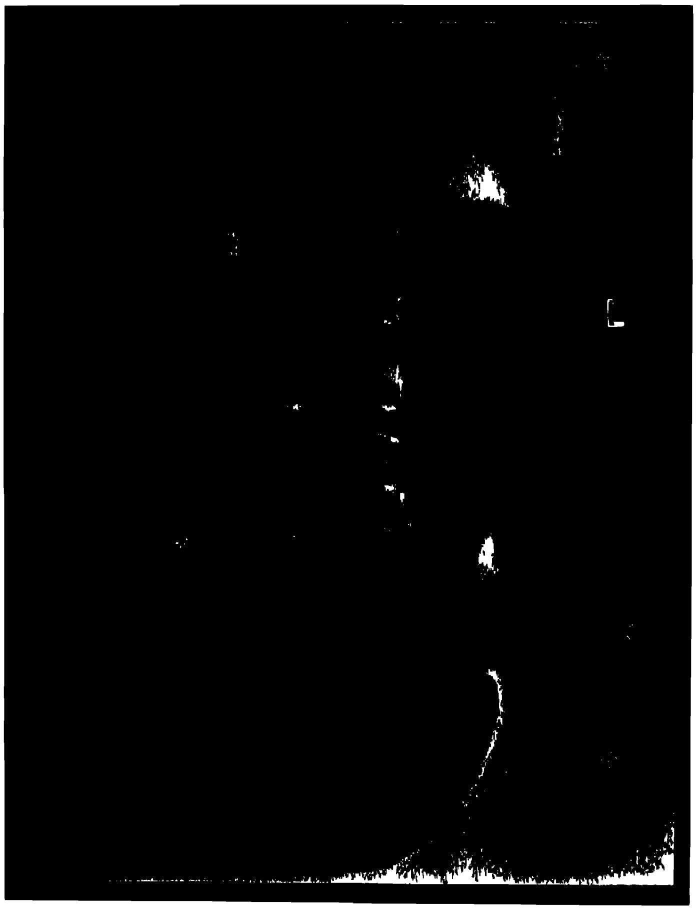
Cone to size of film, $6\frac{1}{2} \times 4\frac{3}{4}$ in.

SECTION 25

Urinary Tract

SECTION 25


978


979

URINARY TRACT

The urinary system extends from the kidneys to the urinary meatus, and embraces the kidneys, the ureters, the bladder, and the urethra (978, 980, 981).

The prostate in the male is also included in this section as the technique applied is similar to that required for the urinary bladder (981).

The *kidneys*, which secrete the urine, are situated in the lumbar region, on the right and left of the spine, between the twelfth dorsal and third lumbar vertebræ, the precise position varying slightly according to the build of the subject. They are oblique in position, with the upper poles nearest the spine, and the left kidney, 12 centimetres in length, is usually slightly longer and more slender than the right, and is usually one centimetre higher.

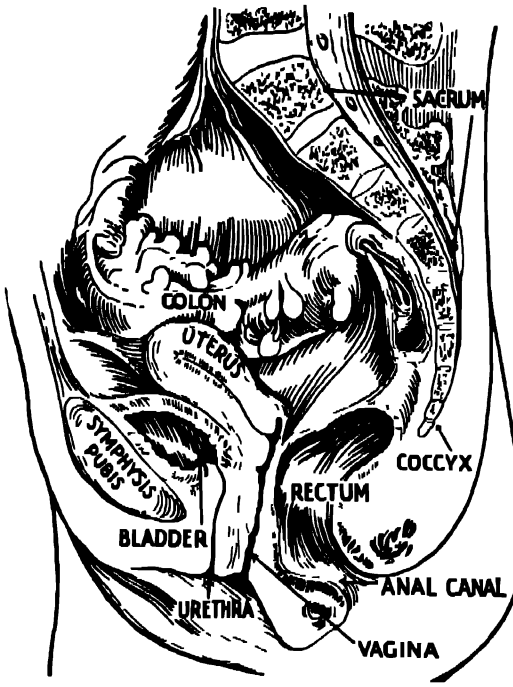
Briefly, each kidney consists of the outer cortex, or solid portion, and the inner, less solid, medulla, which is made up of a series of small tubules, or collecting tubes, surrounded by minute blood vessels, the fluid gathered by the tubules having passage into a number of hollow cavities, named calyces, and thence into the renal pelvis, which last forms the upper, expanded portion of the ureter (978, 979).

The *supra-renal glands* are situated one immediately above the upper pole of each kidney.

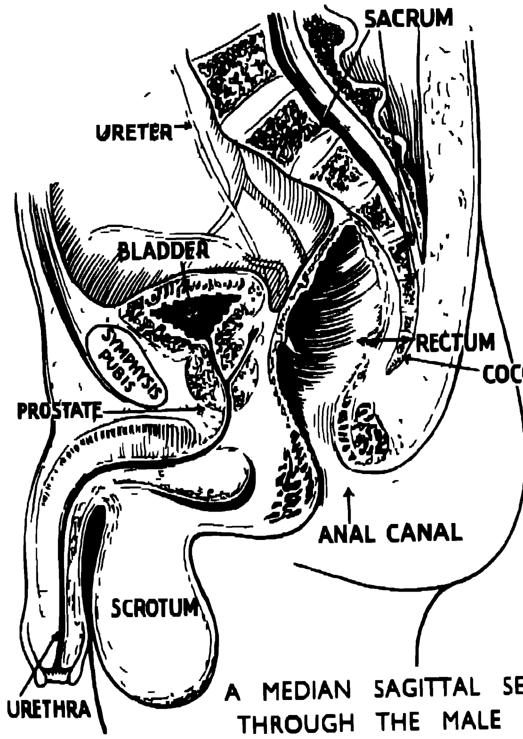
Leading from the expanded renal pelvis, the *ureters* extend downward from the level of the second lumbar vertebra, overshadowing the tips of the transverse processes, to the sacro-iliac region, where they bend toward the mid-line and terminate in the ureteric orifices, 2·5 centimetres apart, in the posterior wall of the bladder (978, 979). The ureters are about 25 centimetres to 30 centimetres long.

The *bladder*, situated in the anterior part of the pelvic cavity, lies behind and just above the symphysis pubis. Its exact position depends largely upon the degree of distension. When empty it is small and adjacent to the symphysis pubis; when full it dilates to form an ovoid organ rising to the level of the sacro-iliac joints, the upper part forming the fundus and the lower, constricted portion behind the symphysis pubis, forming the neck of the bladder, where it joins the urethra, through which the contents of the bladder are voided (980, 981, 982).

The *urethra* extends from the neck of the bladder to the urinary meatus, having in the male a length of 18 centimetres to 20 centimetres (981), and in the female, 4 centimetres (980).



A MEDIAN SAGITTAL SECTION THROUGH THE FEMALE PELVIS **980**



A MEDIAN SAGITTAL SECTION THROUGH THE MALE PELVIS **981**

Urinary Tract

DIFFERENTIATION OF RENAL TRACT SHADOWS

When radiographic exposure conditions are suitable and preparation of the patient is satisfactory, the kidneys, because their density is slightly greater than that of the surrounding tissues, are clearly visible, but the ureters are not shown, and the bladder is only seen when it contains fluid.

The fairly large subject usually produces better kidney shadows than the very thin subject, as the presence of additional perirenal fat in the former gives a general, even opacity against which the kidney shadows show clearly by contrast, films of the very thin subject, on the other hand, producing a confusing mass of tissue detail.

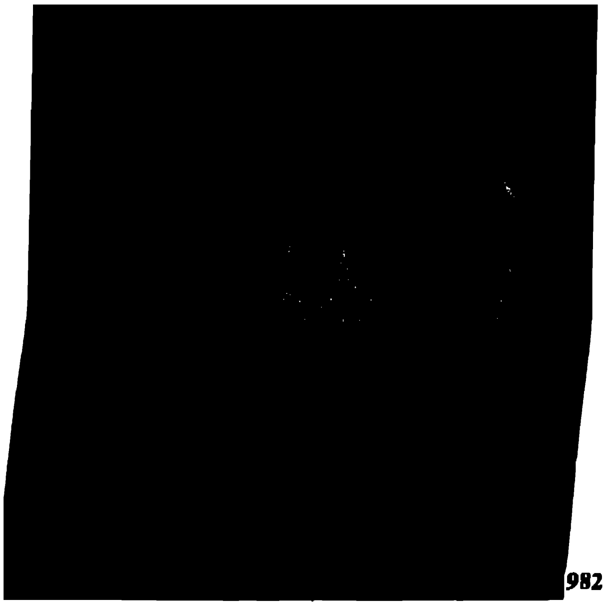
Other soft structures shown in these films are the liver, chiefly on the right side, between diaphragm and lower costal margin, and the psoas muscles on each side of the spine, from the twelfth dorsal region, where they originate, to the iliac crest, toward which they diverge to become lost in the shadow of the iliac bones.

It is sometimes necessary to differentiate between shadows appearing within the region of the urinary tract and those occurring in overshadowing tissues and organs. This is facilitated by variations in respiration and by films taken in other positions than the antero-posterior—postero-anterior, lateral and oblique. Additional information may also be obtained with the patient in the semi-recumbent and erect positions, each part of the tract being dealt with separately.

The quality of radiographs required for examination of the urinary tract should be such that these soft tissue structures are all clearly defined: there should not be the density required for examination of bony structures, so penetration should be less The films are usually a preliminary to the injection of an opaque medium which renders the urinary system visible in varying degree (**979, 982**) according to the method employed, this examination being termed urography, or more generally, pyelography, and the screen examination of the kidneys, pyeloscopy. Various parts of the urinary system may also become visible owing to pathological causes, the most common being the presence of calculi, or accretions of solid matter, which may cause an obstruction to the flow of urine in kidneys, ureters, or bladder (**983, 983a**).

RESPIRATION

As the kidneys move with respiration, exposures should be made during suspended breathing, preferably at the end of complete expiration. It is frequently necessary, however, to expose also on inspiration and during the various stages of respiration (**990, 991**).



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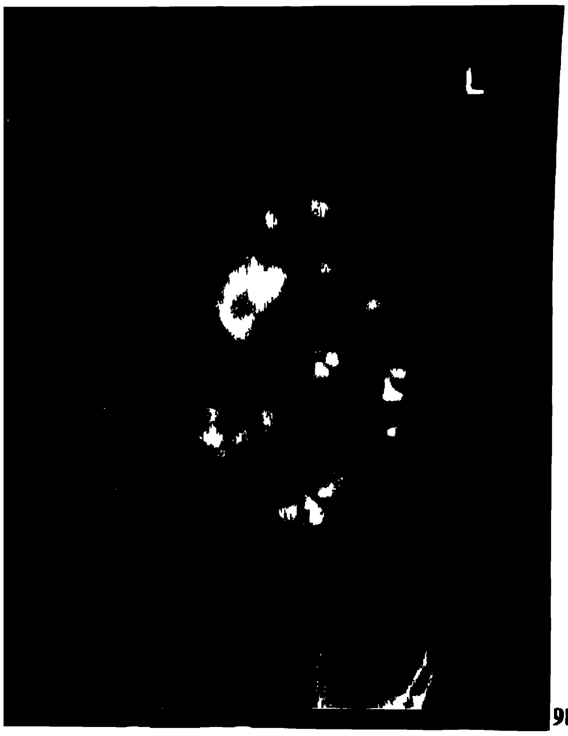


983

983a

Urinary Tract

PREPARATION

The preparation of patients for radiography of the urinary tract frequently presents some difficulty as it is essential for the intestinal tract to be free from gas and fæcal matter. It is considered preferable to prepare the subject over a longer period rather than a short period, as in the latter case the resulting gas shadows may be even more troublesome than the original fæcal shadows. Each X-ray department, however, has its own method of preparing patients for renal examination.

It is usual to give a mild aperient, such as vegetable laxative, on two consecutive nights and to place the patient on a low residue diet on the day prior to the radiographic examination. Food is then restricted from supper the previous night until after the X-ray examination twelve hours later. The out-patient usually responds very well to this treatment, but ward patients have to be treated according to whatever previous routine ward preparation has been given. These subjects sometimes present difficulty owing to over-preparation giving rise to extensive gas shadows in the colon. It is often necessary to restrict aperients for at least three days and, in very difficult cases, to arrange for special treatment with modern gas-eliminating preparations such as Pitressin. Pitressin is the trade name for a preparation of posterior lobe pituitrin, of which an injection of 0.5 cubic centimetre or 1 cubic centimetre is made intra-muscularly at an interval of from $2\frac{1}{2}$ hours to 1 hour before the X-ray examination. The use of a flatus tube immediately before the examination assists in the evacuation of gas concentration from the colon. Charcoal biscuits, given two-hourly during the day prior to the examination, may have the desired effect. In some departments all patients for renal tract investigation are examined without any preparation.

REGION

The region to be covered radiographically extends from the eleventh dorsal level posteriorly, which corresponds with the sterno-xiphoid process anteriorly, to the lower level of the symphysis pubis.

Routine radiographic examinations should include the entire urinary tract. The whole area may be included on one large film, or two films may be taken, one for the kidneys and upper three-fourths of the ureters and the other for the lower third of the ureters and bladder.

POSITIONING

Renal examinations are usually made with the patient in the horizontal position, but there is a tendency, especially in pyelographic examinations, to include films taken in the erect, and sometimes in the sitting, position. The value of these additional films will be appreciated from the illustrations in this section.

Urinary Tract

IMMOBILISATION

A compression device, such as an inflated rubber bag under the Potter-Bucky diaphragm immobilising band, is sometimes used: this serves the purpose of immobilising the kidneys and tends to force the air-filled portions of the colon laterally away from the kidneys; but some radiologists do not allow compression to be used.

For pyelographic examination by excretion pyelography, a cylindrical non-opaque pad made of lamb's-wool may be placed over the lower ureters and compression applied with the Potter-Bucky band. When the compression is used with cone localisation a series of small films may be taken, one for each kidney, one for the ureters, and one for the bladder.

When applying general compression with the Potter-Bucky band great care should be observed, especially with the obese subject, to see that the band is evenly applied, otherwise dense transverse shadows of the compressed tissues will appear. Folds of material between subject and couch will have a similar effect, and unless a sheet free from creases is used it is preferable to place the patient in direct contact with the couch. Ordinary blanket covering between patient and tube will not be shown on the film, and the patient, therefore, should never be exposed: in cold weather warm blankets may be used during the exposure, movement due to shivering being thus prevented as far as possible.

EQUIPMENT

The urography table, a combination of theatre operating table and X-ray couch specially designed for this work, enables all catheter injections to be made under ideal conditions, the injections being quickly followed by the X-ray exposure. This table usually forms a part of the urological theatre equipment, which includes also an X-ray unit, or a room in the X-ray department may be reserved and equipped for urography.

EXPOSURE FACTORS

It is important to use a fairly short exposure technique—from a half to one second. A high milliamperage unit will allow the exposure to be reduced to one-tenth of a second. Penetration may be varied from 60 kilovolts to 75 kilovolts according to the size of the subject and the intensifying screens in use.

There is a tendency to increase the anode-film distance in order to avoid enlargement distortion of the kidneys. In addition, a 48 inch anode-film distance allows the whole of the renal tract to be included on a single 15 inch by 12 inch film, which is not possible at a 30 inch distance.

Intensifying screens and the Potter-Bucky diaphragm are used for all renal examinations.

IDENTIFICATION OF FILMS

Identification of patient, right or left side, date, and, for pyelographic examinations, time of taking, are imperative details to be noted in the case of each film exposed, as surgical removal of one kidney may be advised.

SECTION HEADINGS

This section is given under two headings:—

(1) Preliminary examination:

(2) Urography:

urography being again sub-divided and discussed under four headings:—

(*a*) Pyelography:

(*b*) Ureterography:

(*c*) Cystography:

(*d*) Urethrography:

of which (*a*) pyelography and (*b*) ureterography are each treated with reference to two methods -intravenous and retrograde.

The opaque media used for the investigation of the urinary tract are various preparations of iodine, which are obtainable under several trade names, such as Per Abrodil, Uroselectan B, Pyelectan and Uropac, or a less costly form for retrograde injection is a 10 per cent. to 20 per cent. solution of sodium iodide.

The exposure factors in this section refer to an adult male subject of 157 pounds weight, having a height of 5 feet 8½ inches, and having at the second lumbar level an antero-posterior thickness of 9 inches and a lateral thickness of 10¾ inches.

Exposure factors for the positions shown on pages 378 and 379, are as follows:—

Renal Tract EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	165	100	48″	Ilford	Tungstate	Potter-Bucky
70	66	40	30″	Ilford	Tungstate	Potter-Bucky
70	83	50	48″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 15 × 12 in. or 17 × 14 in.

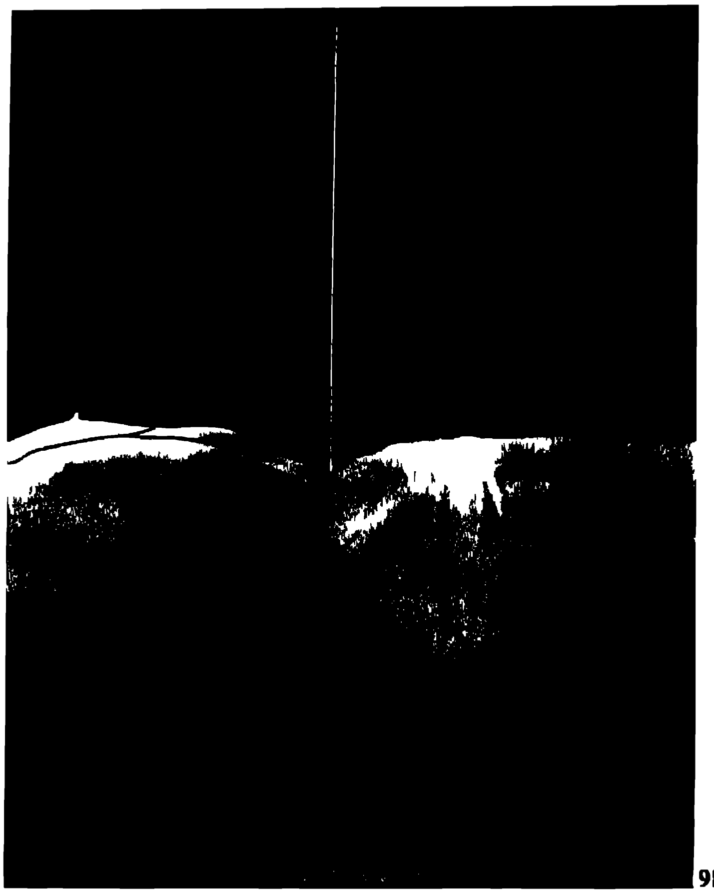
Bladder EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	82	50	33″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 10 × 8 in.

Urinary Tract: Preliminary Examination

Single Film Technique



984

The preliminary examination may be made on one film, or two films may be used, one for the kidneys and ureters and the other for the lower ureters and bladder.

KIDNEYS, URETERS AND BLADDER

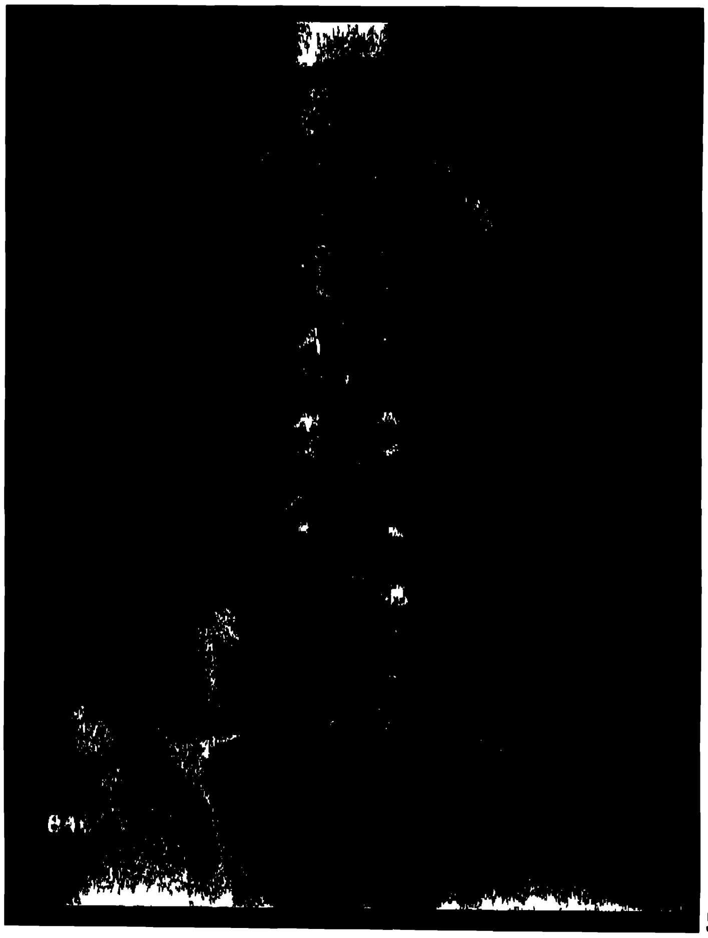
The patient is supine in the middle of the Potter-Bucky couch, with the knees or shoulders slightly raised to assist in straightening out the lumbar arch in order to bring the kidneys as near as possible to the film.

The 17 inch by 14 inch film is placed in position so as to include from the upper poles of the kidneys to the urethra —from the eleventh dorsal vertebra to the lower level of the symphysis pubis.

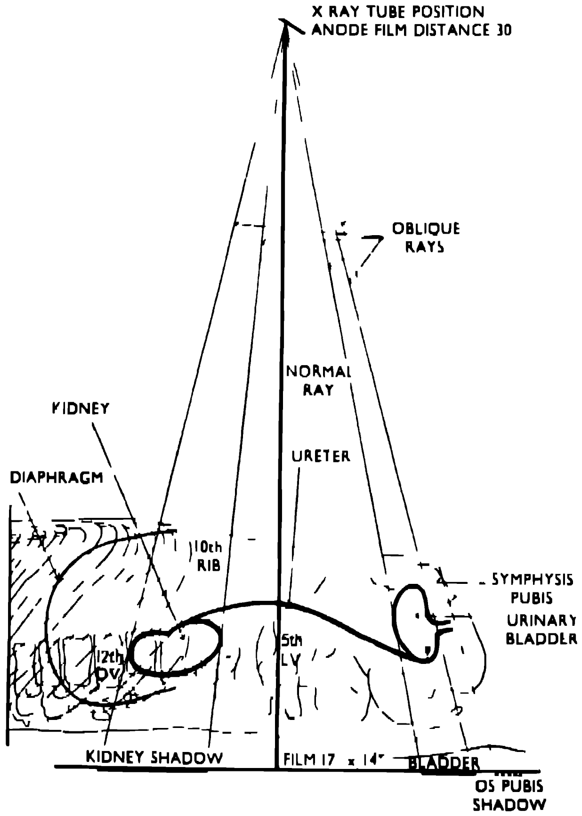
CENTRE in the mid-line, at the level of the fourth to fifth lumbar vertebræ The exposure is made on expiration, with additional films on inspiration as required.

(978, 984, 985, 986)

The exposure factors for this position are shown on page 377.

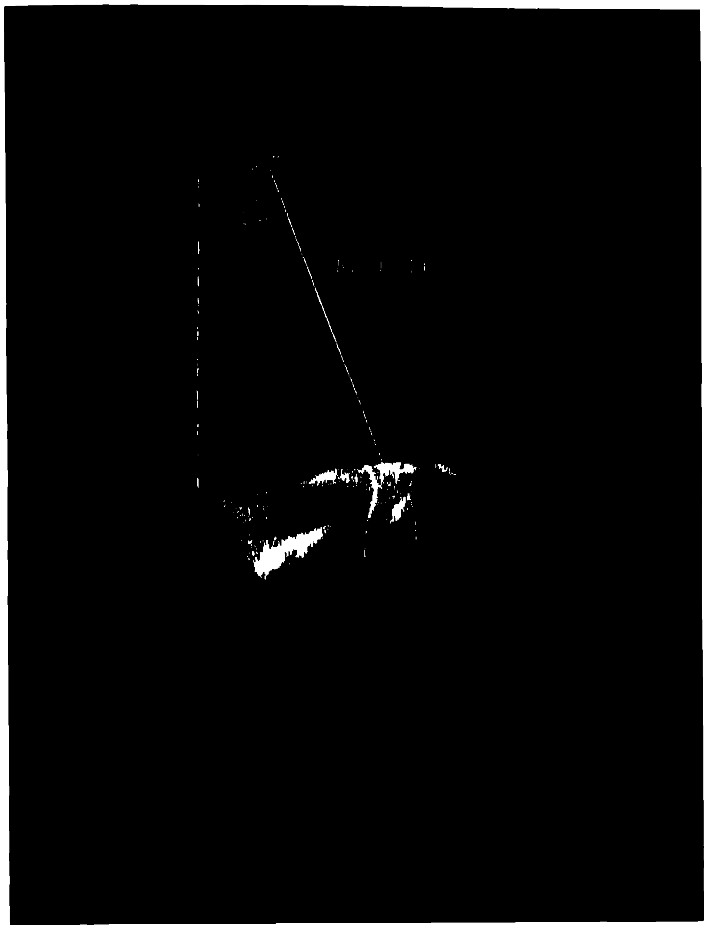


985



986

The longitudinal sectional diagram **(986)** shows the projection of the urinary tract shadows when the exposure is made from a distance of 30 inches, although, in practice, to include the whole tract on a 15 inch by 12 inch film a 48 inch anode-film distance is necessary **(978)**.



987

988

Double Film Technique

The purpose of using two films is to obtain a duplicated view of the ureters passing over the sacro-iliac region. The bone structures in this region are so dense that a small abnormal shadow in the ureter may, in a single film, easily be lost in the bone shadows, and a second film taken of the same region, but from a different aspect, may establish identification.

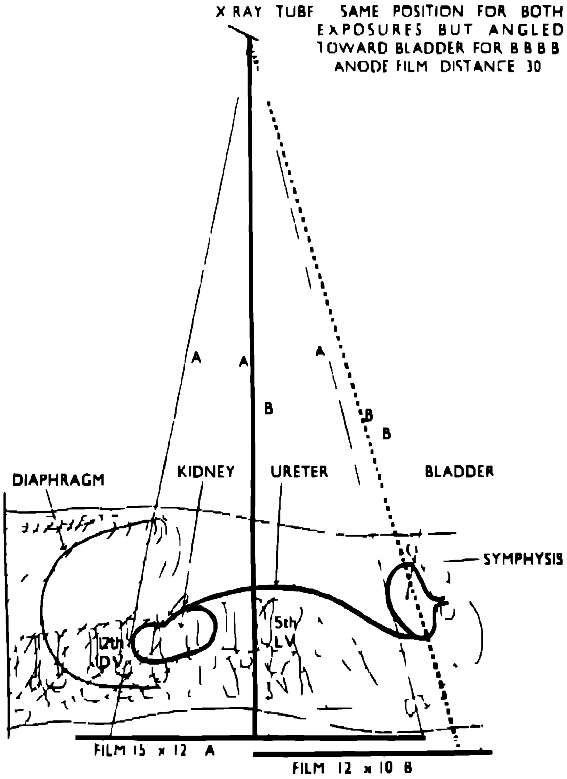
KIDNEYS AND URETERS

For the first of the two films, with the patient supine, a 15 inch by 12 inch film is placed in position to include the kidneys, ureters, and the upper border of the bladder.

CENTRE in the mid-line, at the level of the lower costal margin (985, 987).

BLADDER

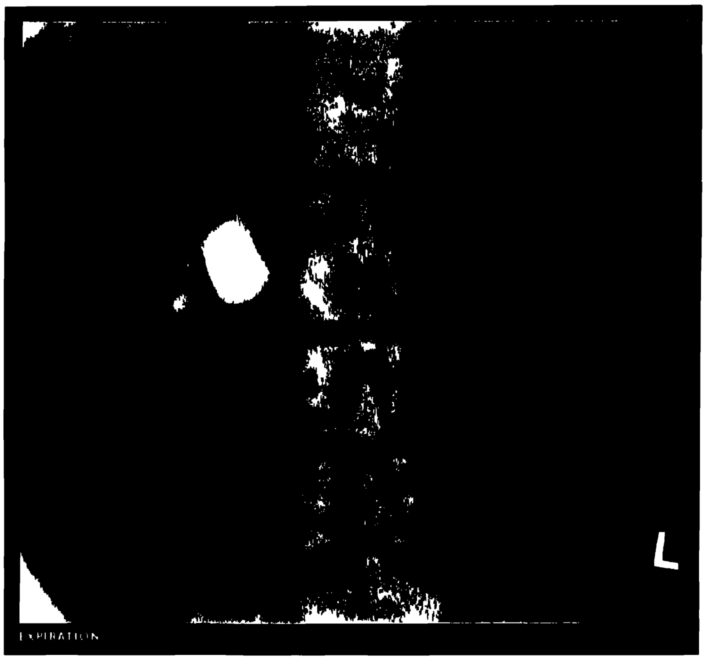
For the second film the patient remains in the same position as for the first, and the tube, the level of which is unchanged, is angled toward the feet to enable the central ray to pass above the symphysis pubis at an angle of from 15 degrees to 25 degrees. The film is displaced toward the symphysis pubis to accommodate the oblique projection and so to include the whole of the bladder region and the lower third of the ureters. Owing to the obliquity of the beam the anode-film distance is slightly increased (987, 988, 989). Exposure factors are on page 377.



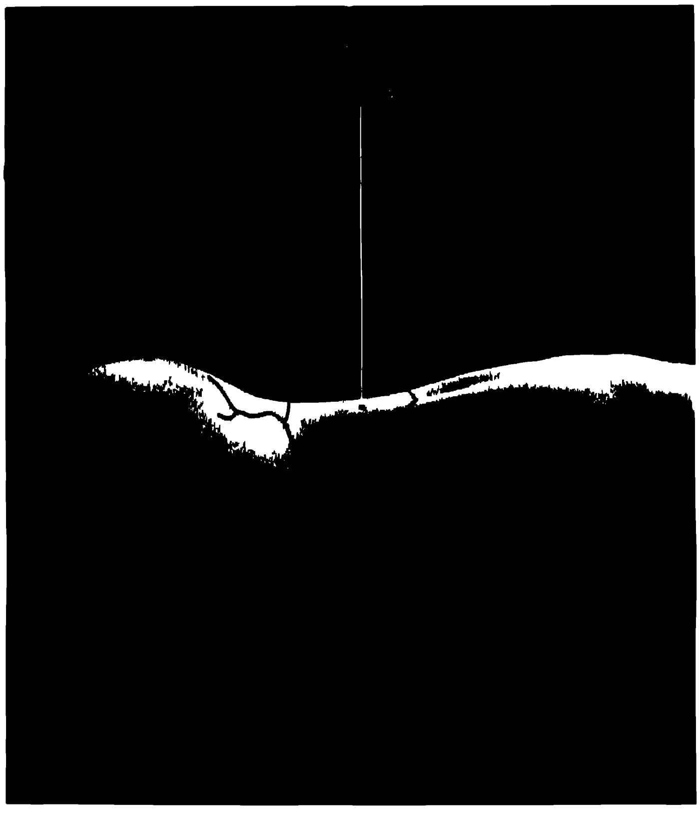
989

The longitudinal sectional diagram (989) shows the two tube projections for double film technique, and should be compared with (986).

990



991


992

Urinary Tract: Preliminary Examination

DIFFERENTIATION OF ABNORMAL SHADOWS

When abnormal shadows are shown in the preliminary film, further preliminary X-ray investigation may be undertaken to localise these shadows should their appearance not identify them as typically renal.

Shadows over the right kidney, for example, may coincide in position with abnormal shadows in the gall bladder or calcification in lymphatic glands on the posterior abdominal wall, and should be investigated accordingly.

DISPLACEMENT OF SHADOWS ON RESPIRATION

An additional film may be taken on *inspiration* to show whether the shadows retain their relationship with the kidney outline as compared with the original film on *expiration*. For greater clarity two pyelography radiographs have been used to illustrate this, **(990)**, taken on inspiration and **(991)**, taken on expiration. The level of the shadows of the kidneys in the two films should be noted, the first lumbar vertebra having been lettered to show a similar bone level in each. It will be found that shadows outside the kidneys move in varying degree, during breathing, in relationship to the kidney outline, and their position can thus be established.

(990, 991)

DISPLACEMENT OF SHADOWS DUE TO POSITION OF PATIENT

In addition to the antero-posterior views exposures may be made from postero-anterior, lateral and oblique aspects, any of which may serve to confirm or refute the evidence of abnormal shadows within the renal area. Stereoscopic films also may be taken from any aspect.

The technique for the various positions mentioned is as follows:—

POSTERO-ANTERIOR

The patient is examined in the prone position, using the same technique as for the gall bladder. As compared with the antero-posterior film the shadows may or may not retain their relationship with the renal outline or with each other. Size and definition also will vary according to the distance of the shadows from the film, as discussed in gall bladder technique, page 367.

CENTRE in the mid-line, at the level of the lower costal margin.

(992)

The exposure factors are similar to those required for the antero-posterior view.

993

994

Urinary Tract: Preliminary Examination

LATERAL

The patient is turned on to the affected side and supported in position as previously described for the lateral lumbar spine, on page 136

CENTRE at the level of the lower costal margin

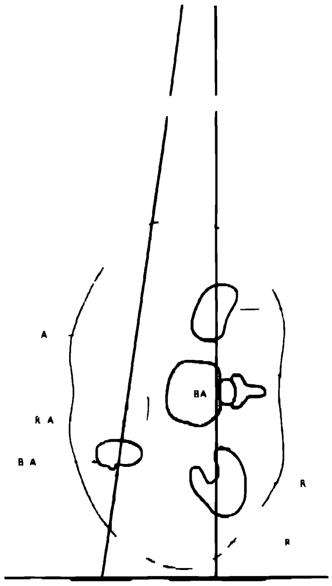
Shadows in the kidneys will overshadow, or be very near to, the vertebræ Those outside the kidneys are usually shown anterior to the spine

(993, 994, 995)

EXPOSURE FACTORS

kVp	mA Secs Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
85	160	97	48	Ilford	Tungstate	Potter Bucky
85	107	65	48	Ilford	Fluorazure	Potter Bucky

Cone to size of film, 17 × 14 in or 15 × 12 in



995

The cross-sectional diagram (995) shows the projection of kidneys and gall bladder from the lateral aspect.

Urinary Tract: Preliminary Examination

DIFFERENTIATION OF BLADDER SHADOWS

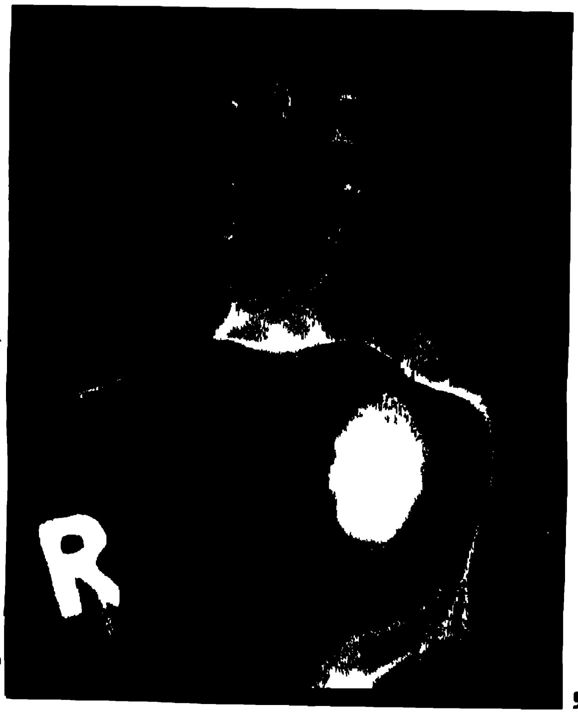
To identify within the bladder field shadows which may be confused with prostatic or other shadows, the lower end of the couch may be raised until the patient is inclined at an angle of approximately 15 degrees, when any free body within the bladder, which should be full for this purpose, will tend to fall toward the fundus, whereas stationary opacities, such as prostatic calculi, will retain their position relative to adjacent bone structures.

CENTRE above the symphysis pubis, with the tube angled 15 degrees toward the feet (**996, 997, 998**).

A film taken from the postero-anterior aspect with the patient *lying on the side* (**937**, page 354) will give a similar result when the bladder is full, the free shadows in this case falling to the lower side.

996

997



998

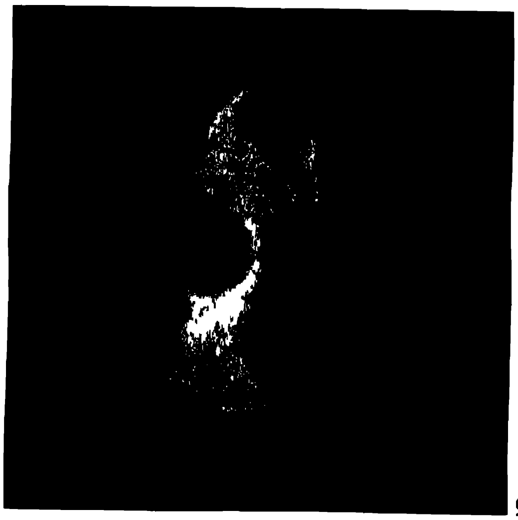
ISOLATED KIDNEY TECHNIQUE

A request for the radiographic examination of the kidney during operation or as a pathological specimen after removal is not infrequent. In either case an adjustment in the exposure factors is essential to produce soft tissue shadows in such a small body, and before an initial examination of this kind is undertaken in the operating theatre, the radiographer is advised to check the technique by exposing a specimen kidney from the pathological department. The strictest aseptic precautions will, of course, apply in the theatre (**999**).

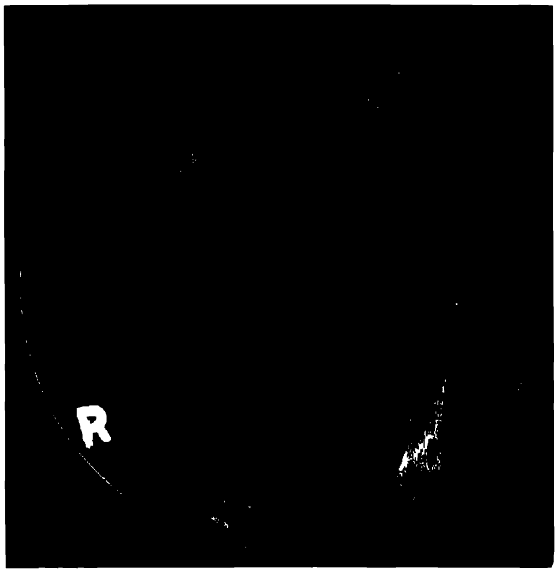
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford
A 30	264	160	30"	Ilfex	—
B 55	50	30	30"	Ilfex	—

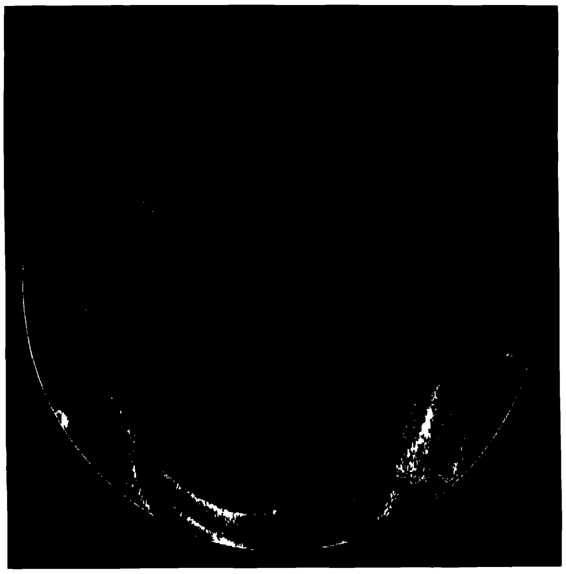
A. Pathological specimen. B. During operation.



999



1000



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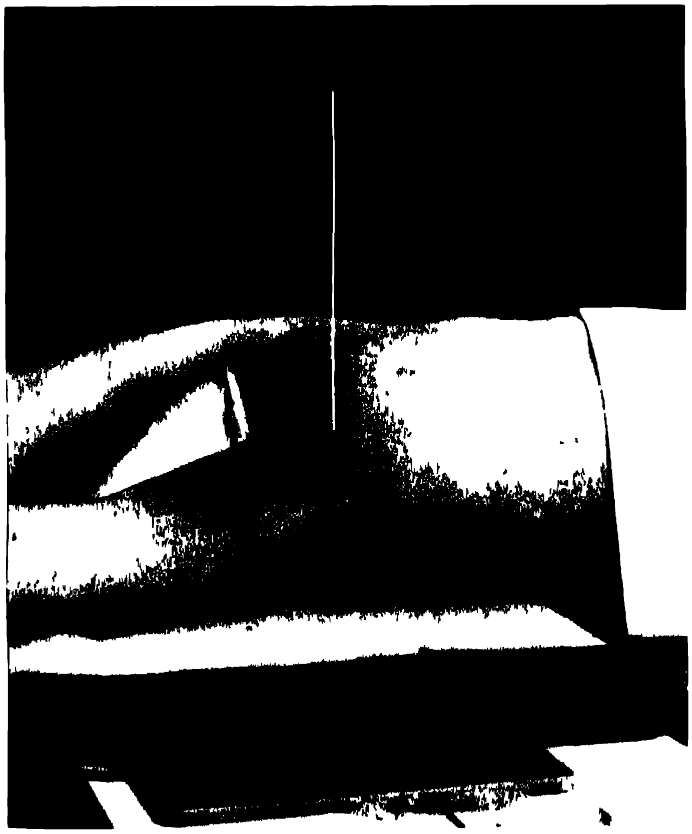


1002

Urinary Tract: Opaque Bougee

URETERS

Investigation of the ureters for localisation of abnormal shadows, apart from double film technique and stereoscopic views, is beyond the scope of the ordinary preliminary examination and may involve the introduction of an opaque bougee into the ureter. The bougee is a blind ureteric catheter and, being opaque to X-rays, serves to show the position of the ureter, the relative position of opaque shadows in the region of the ureter, and the position of an obstruction in the ureter itself. An opaque ureteric catheter serves the same purpose. Either of these ureteric investigators may be introduced, with the aid of a cystoscope, during cystoscopy.

The cystoscope is an instrument used for viewing the interior of the bladder, during which process the fine ureteric catheter or bougee is introduced through the minute bladder orifice of the ureter, and passed up the ureter to the entrance of the renal pelvis unless its progress is arrested by some obstruction **(1000, 1001)**.

A radiograph taken from the antero-posterior aspect to show the position of the bougee indicates the further X-ray investigation required.

The progress of the bougee may be arrested by the opacity already shown in the preliminary film, or by some non-opaque obstruction. On the other hand, it may pass on to overshadow the opacity.

TUBE SHIFT

In the latter case an additional film may be taken without moving the patient but with the tube displaced transversely by 10 centimetres to 15 centimetres, producing, with the first film, a stereoscopic pair which may be viewed as such; or the second film may show more or less separation of the two shadows. Two films show the effect of the tube shift **(1000, 1001)**.

OBLIQUE

Alternatively, the second film may be taken with the patient in the oblique position.

The patient is turned through approximately 30 degrees, with the unaffected side raised on non-opaque pads.

CENTRE in the line of the ureter, over the affected area. **(1002)**

Either of these additional films should show the relationship between the opaque shadows and ureter.

Urinary Tract

Urography

Urography is the term used to denote a complete radiographic survey of the whole of the urinary tract after the introduction of an opaque medium and includes:—

Pyelography.—Pelves of the kidneys:

Ureterography.—Ureters:

Cystography.— Bladder:

Urethrography.— Urethra.

Pyelography and Ureterography may be carried out in two ways—the intravenous, or descending, method, and the retrograde, or ascending, method. Ureterography is not usually specified as such, the complete examination being generally named pyelography.

Intravenous or Descending Pyelography

The preparation of the patient is the same as for the preliminary examination of the urinary tract, with the addition of the restriction of fluids for at least six hours—preferably longer—before the examination; and the contents of the bladder are voided immediately preceding the injection.

Preliminary films should always be available at the time of the injection.

The opaque material, or "dye," used contains 40 per cent. iodine, organically combined so that the iodine is not freed into the general system and therefore has no ill effects. It is a preparation which is excreted by the kidneys, rendering the urine in the kidneys, ureters, and bladder opaque to X-rays, and is finally excreted from the body with the urine as a foreign substance.

The opaque medium is supplied under various trade names, such as Uroselectan B, Per Abrodil, Pyelectan and Uropac, and is packed in 20 cubic centimetre ampoules already sterilised for immediate use, one ampoule being the dose required for the average adult subject. For children aged between 9 and 14 years the quantity should be reduced by one third, a half quantity being appropriate for children between the ages of 5 and 9 years and a one-third quantity for those of less than 5 years.

It is essential for the injection to be given with the patient already in position on the X-ray couch, and there should be no movement from the couch until the examination is complete, unless functioning is unduly delayed or additional films are required with the patient in the erect position.

The dye is usually injected into a vein at the anterior surface of the elbow, and patients sometimes complain of pain in the shoulder immediately after the injection. A mild rigor may occur, or there may be a sensation of nausea, but normally little discomfort is felt. It is essential, however, that the patient be kept warm throughout the examination, a hot water bottle placed at the feet being generally much appreciated.

Each X-ray department has its own routine timing for exposing the films following the injection. They may be at 5 minutes, 10 minutes, 25 minutes, and from 45 minutes to 60 minutes, but when, as is sometimes the case, the kidneys do not outline during this period and there is no indication of the dye in the bladder, it is necessary to continue the taking of films over a much longer period, probably at 3 hours, 6 hours, 12 hours, or even 24 hours.

Unless proper care is taken the dye may reach the bladder before a sufficient concentration has occurred to outline the kidneys and ureters. This can be avoided by applying compression over the lower ureters. The compressor may be in the form of a cylindrical pad made of lamb's-wool, measuring 7 inches in length and 3 inches in diameter, placed over the ureters at the level of the sacro-iliac joints and held in position by the Potter-Bucky compressor band, firm pressure being applied, and care being taken to see that the compressor pad is kept central over the ureters. All authorities do not agree with this method of obtaining a concentration of dye in the kidneys and upper ureters, preferring to record the normal functioning of the kidneys.

It is important in a pyelographic examination that the whole tract be included on the same film, a 17 inch by 14 inch or a 15 inch by 12 inch film being used according to the size of the patient and the anode-film distance employed.

EXPOSURE FACTORS

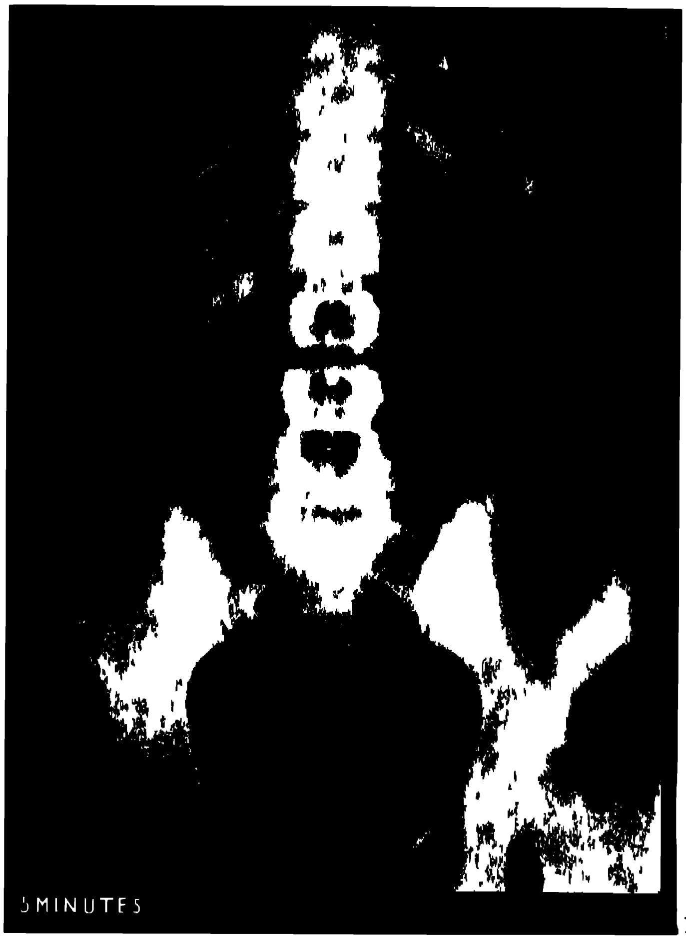
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	66	40	30″	Ilford	Tungstate	Potter-Bucky
70	165	100	48″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 15 × 12 in. or 17 × 14 in.

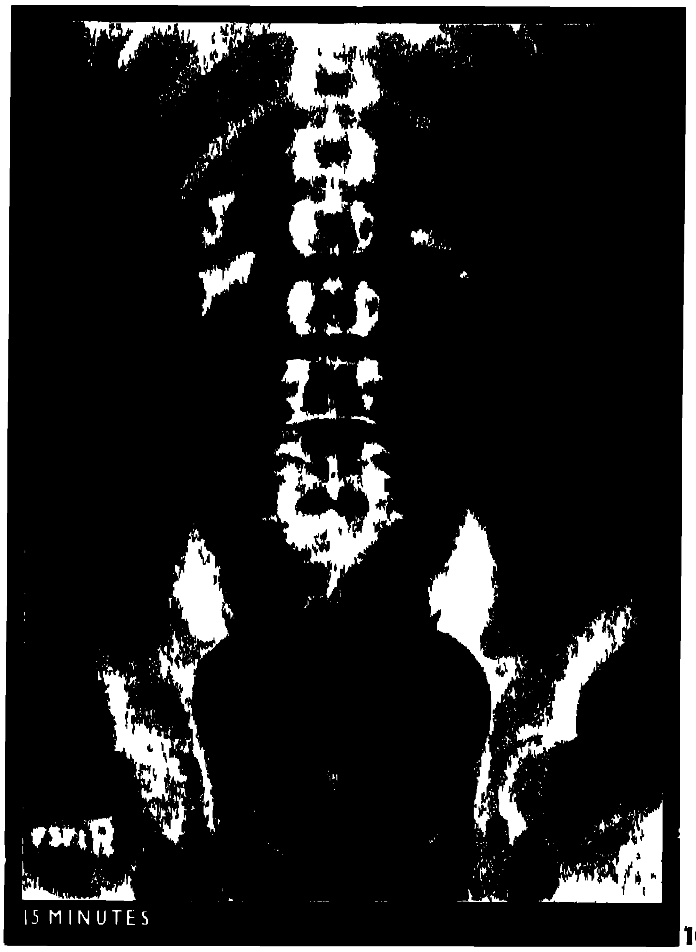
It is of importance, also, to identify each film with care, especially as regards right and left, and the time which has elapsed between injection and exposure.

The series of films shows increasing and subsequent decreasing of density in the kidney substance, and dense shadows of the calyces, the pelvis, the ureters, and, in later films, the bladder. The functioning of the tract is also shown and, what is particularly useful, the comparative functioning of the kidneys.

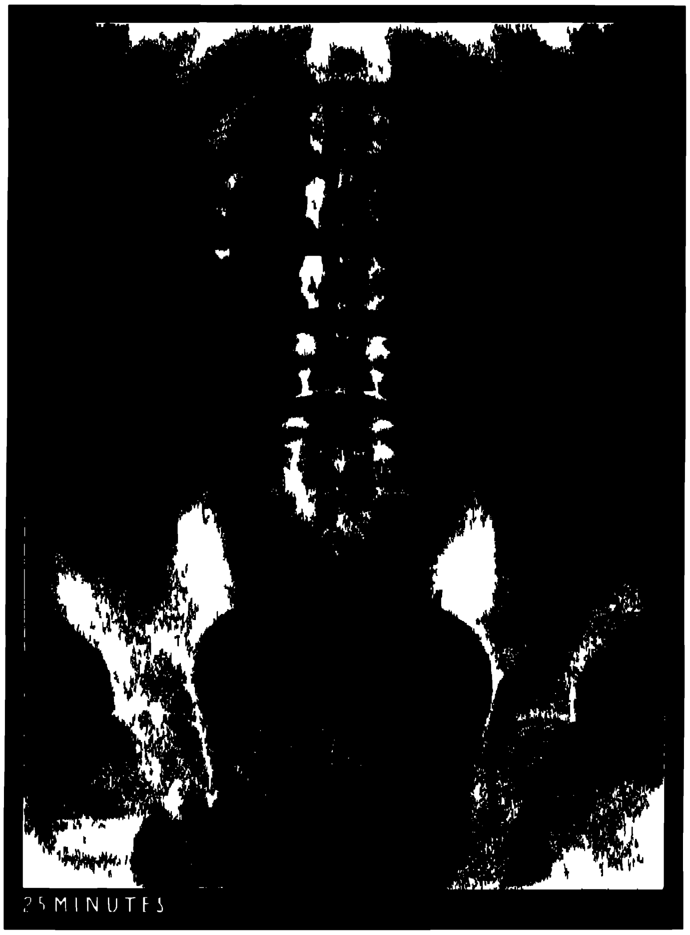
The series of pyelography films **(1003)** to **(1005)** was taken without compression.



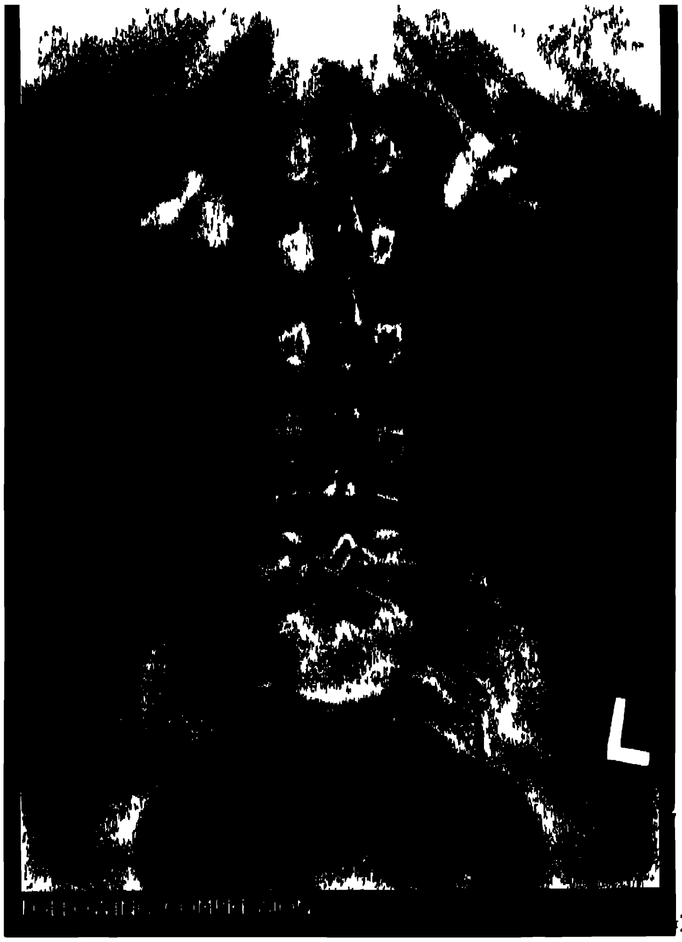
1003



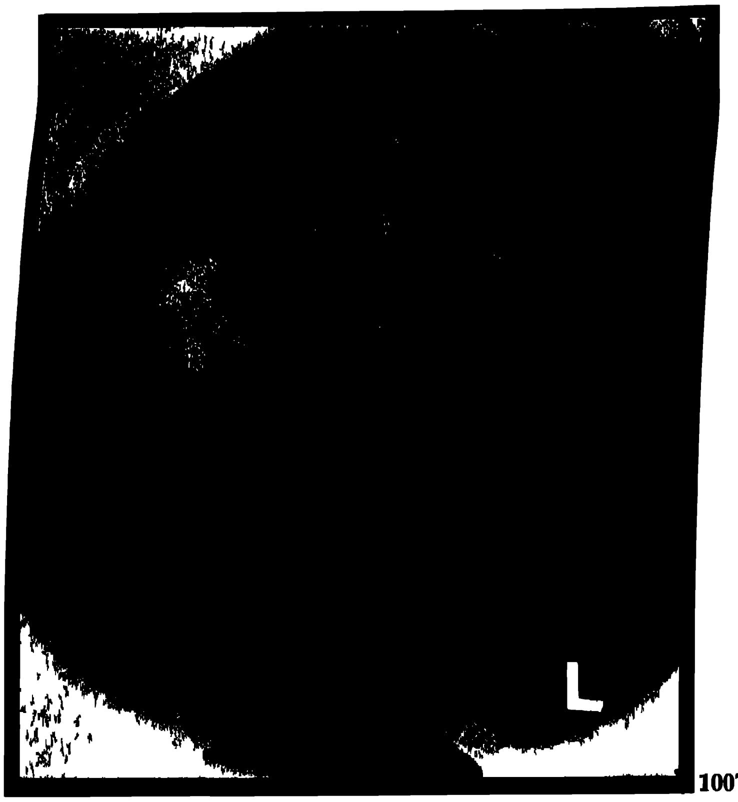
1004



1005



1006



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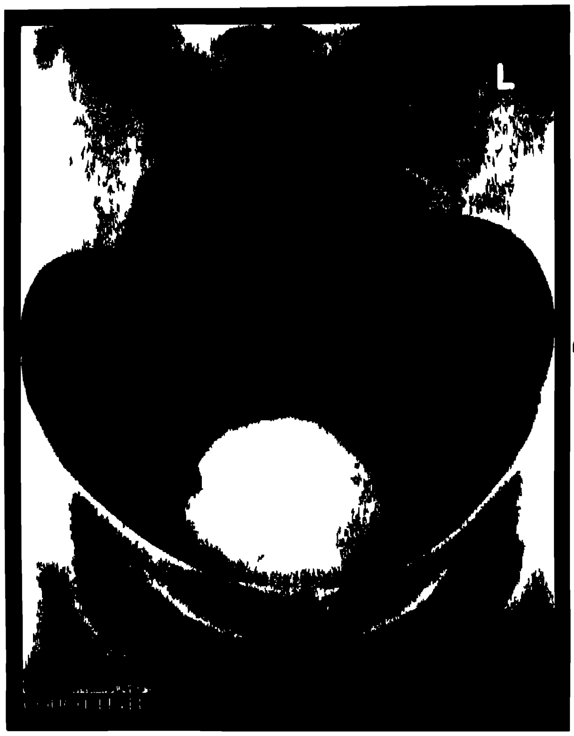
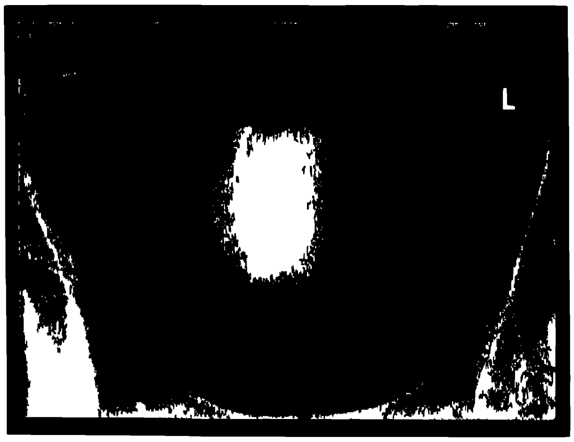


1008



1009

INTRAVENOUS *(continued)*

Film **(1006)** shows the effect of compression, the kidneys and ureters being well filled

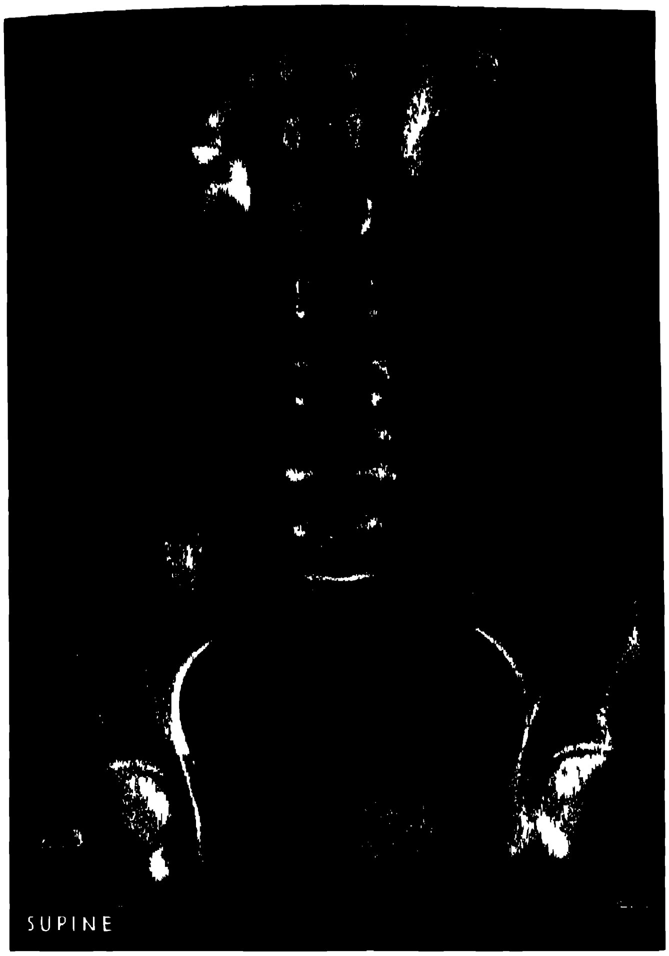
Three films taken of the same patient **(1010)**, **(1011)** and **(1013)**, show the possible variation in the position of the kidneys and the ureters according to whether the patient is supine, erect, or sitting

When the antero-posterior view shows the kidney to be rotated **(1010)** an additional lateral view should be taken **(1012)**

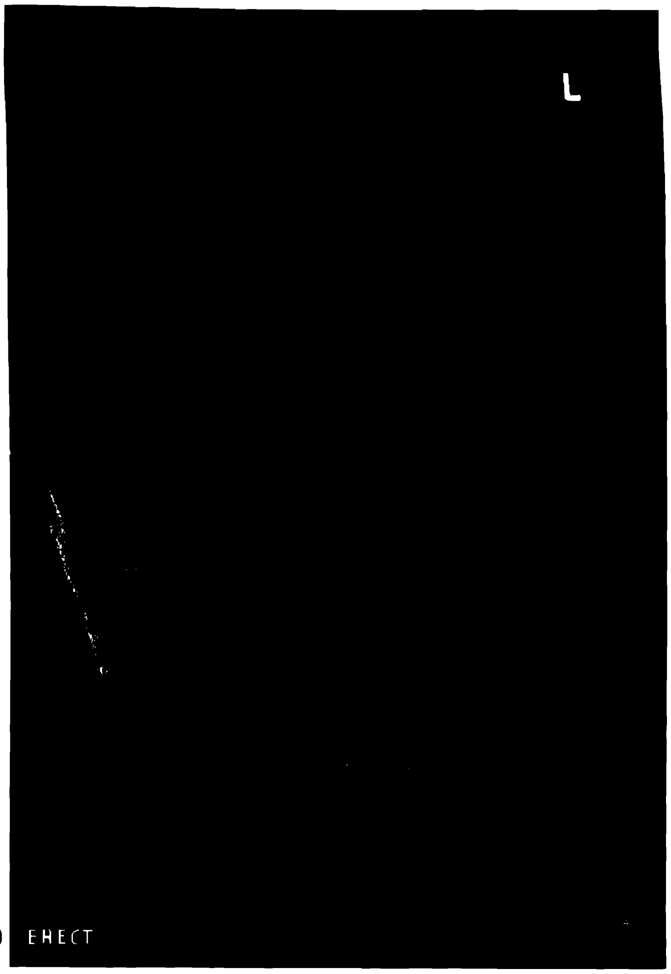
An obstruction in the ureter may give rise to a condition known as hydronephrosis, which shows as a large and distorted shadow of the pelvis and calyces **(1007)**. When such an obstruction is situated low down in the ureter it may be hidden by the opaque dye which has entered the bladder by way of the unobstructed ureter **(1008)**, in which case it may be advisable to raise the foot of the couch and so cause the dye to occupy the portion of the bladder above the ureteric orifices **(1009)** Comparison should be made between the films resulting from the two couch positions **(1008, 1009)** Films may alternatively be taken after micturition when the bladder should be empty

To complete the examination films may be exposed to show the bladder from the right and left oblique aspects, as described in the following pages under Cystography, page 391

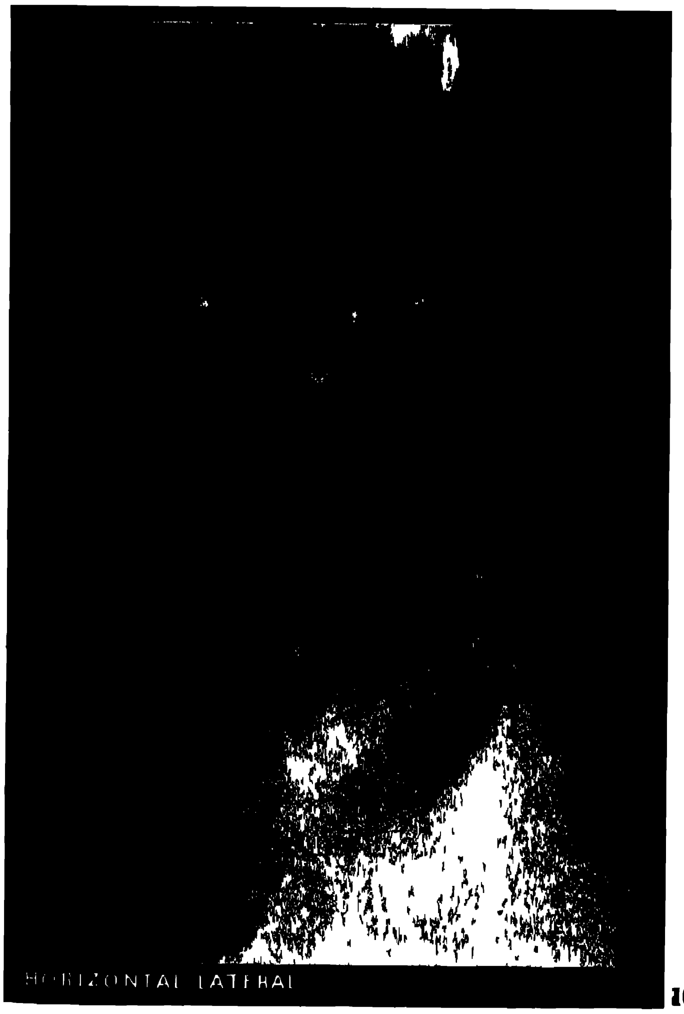
It should be noted that *intravenous* pyelography is also frequently referred to as *excretion* pyelography.



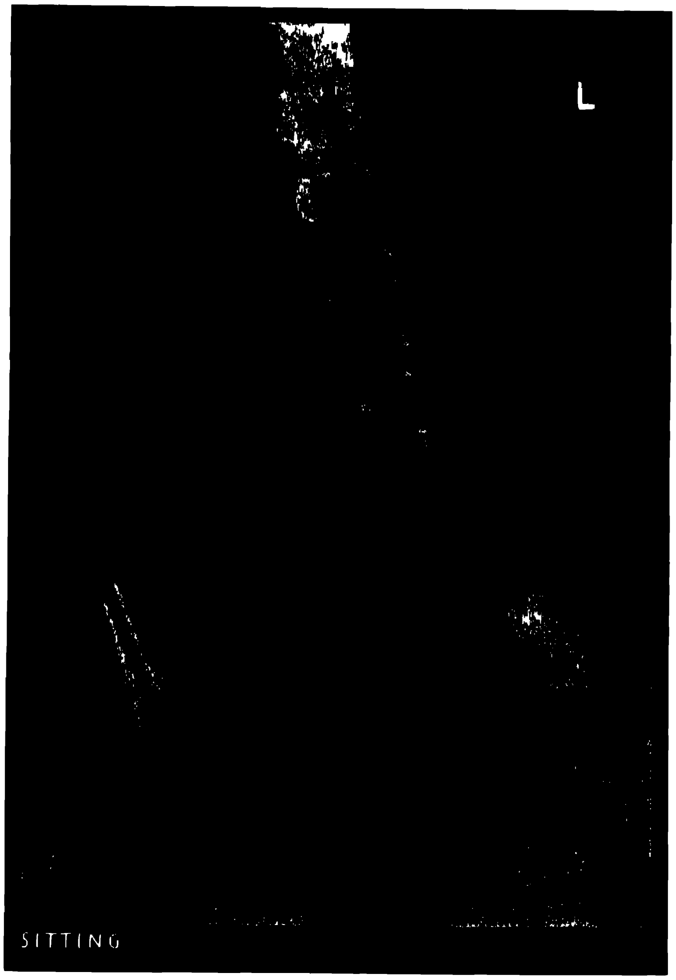
1010



1011



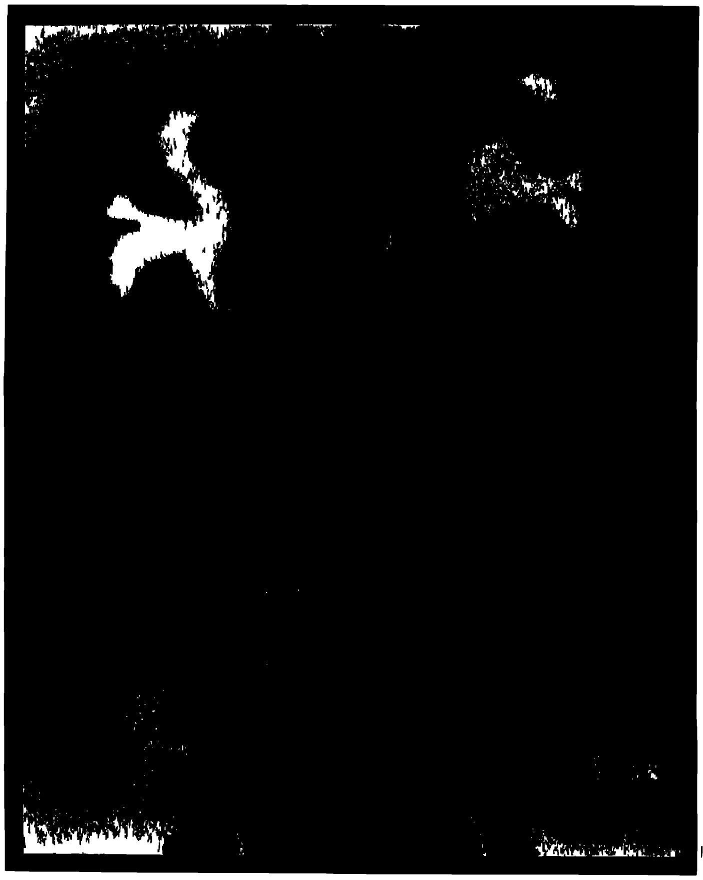
1012



1013

Retrograde or Ascending Pyelography

1014


1015

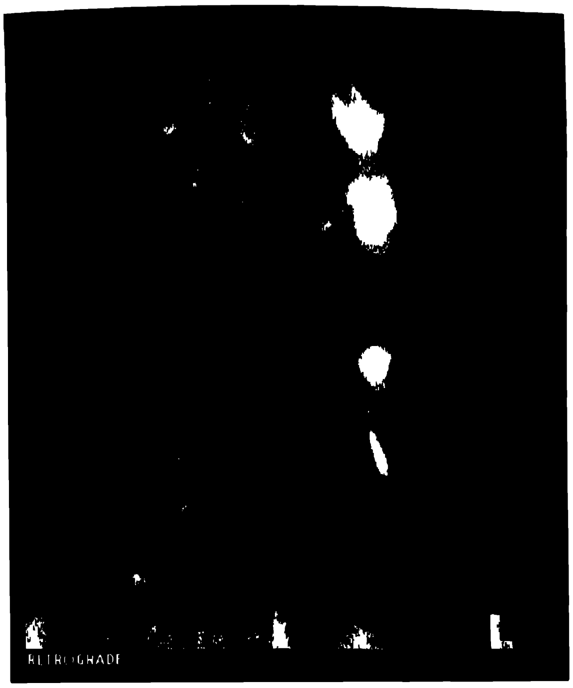
Retrograde pyelography may precede or follow the intravenous method, or it may be the only pyelographic examination made.

The dye outlines the calyces and pelves of the kidneys, but does not in any way show the *functioning* of the kidneys. By the intravenous method the kidneys may function so rapidly that the critical moment of maximum concentration of the dye may be missed, or kidney functioning may, on the other hand, be so slow that there is never a sufficient concentration of the dye to give a good radiographic image. Mechanical filling of the calyces and pelves by the retrograde method may then be applied to advantage.

The two radiographs **(1016)** and **(1016a)** should be compared, as they show, respectively, the effect of retrograde and intravenous pyelography applied to the same patient.

The cystoscope is passed into the bladder, and the opaque ureteric catheter introduced well up into the ureter, this part of the examination being generally carried out in the operating theatre, unless suitable facilities—special urological equipment are available in the X-ray department. The patient is then carefully positioned for the X-ray examination and everything prepared for the film to be taken immediately the surgeon has injected the opaque dye. If desired, the injection may be carried out during a screen examination of the kidneys. A 10 per cent. to 20 per cent. solution of sodium iodide may be used, or the same preparation as is used for the intravenous method. The latter is the more expensive, but if undiluted gives a denser shadow and is, moreover, non-irritating. The surgeon injects from 5 cubic centimetres to 20 cubic centimetres of the solution, injection being continued until the patient complains of slight discomfort in the loin, and then indicates when the first exposure may be made. It is usual for the pressure on the syringe to be maintained during the taking of the film, or the dye may empty from the pelvis of the kidney before the exposure can be made. Either one or both sides may be examined, the kidneys being injected and filmed separately **(1014)**, although the dye may be retained long enough to permit both sides to be shown on a single film **(1015)**.

When exposing separately, and to avoid using a 15 inch by 12 inch film for each side, a narrow 15 inch by 6 inch film may be packed in one side of the cassette, which, with the packed side suitably disposed, is placed in the centre of the Potter-Bucky tray, with the patient central on the couch.



1016

1016a

Urinary Tract: Urography—Pyelography

RETROGRADE (*continued*)

As has been indicated, modern operating theatres include an X-ray urological table and equipment, so that the whole process may be carried out in the theatre; or a small urological theatre may form a part of the X-ray department.

PYELOSCOPY

Pyeloscopy is the term applied to the visual examination of the kidneys by the application of the fluorescent screen during intravenous or retrograde pyelography.

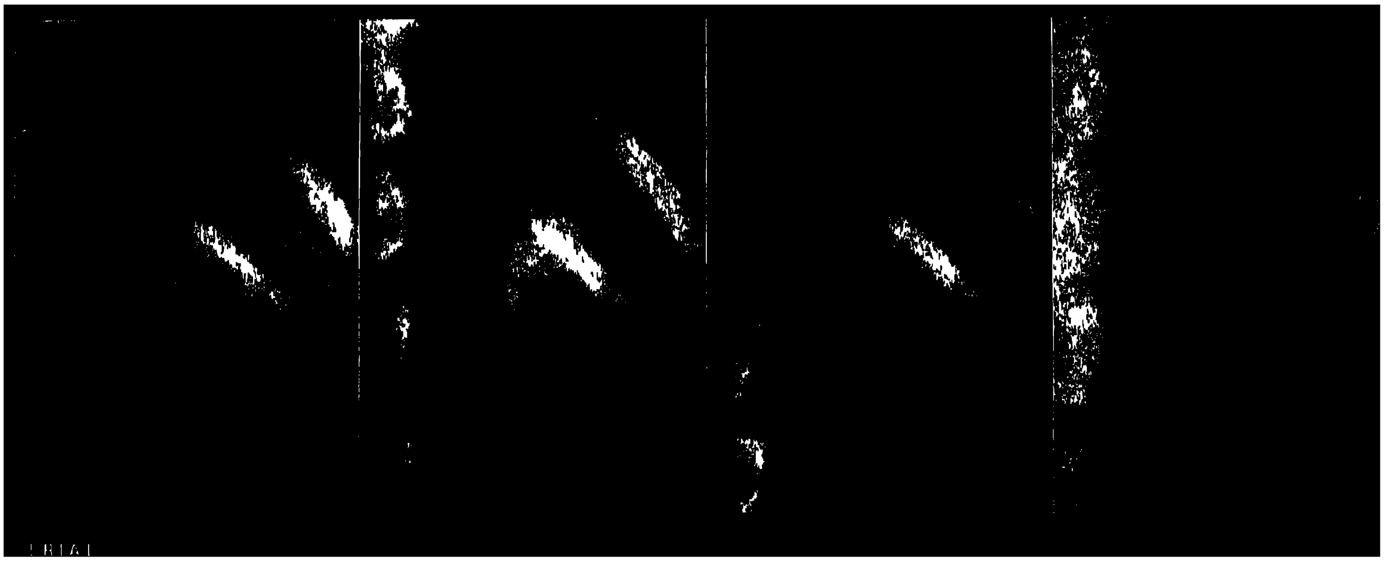
SERIAL PYELOGRAPHY

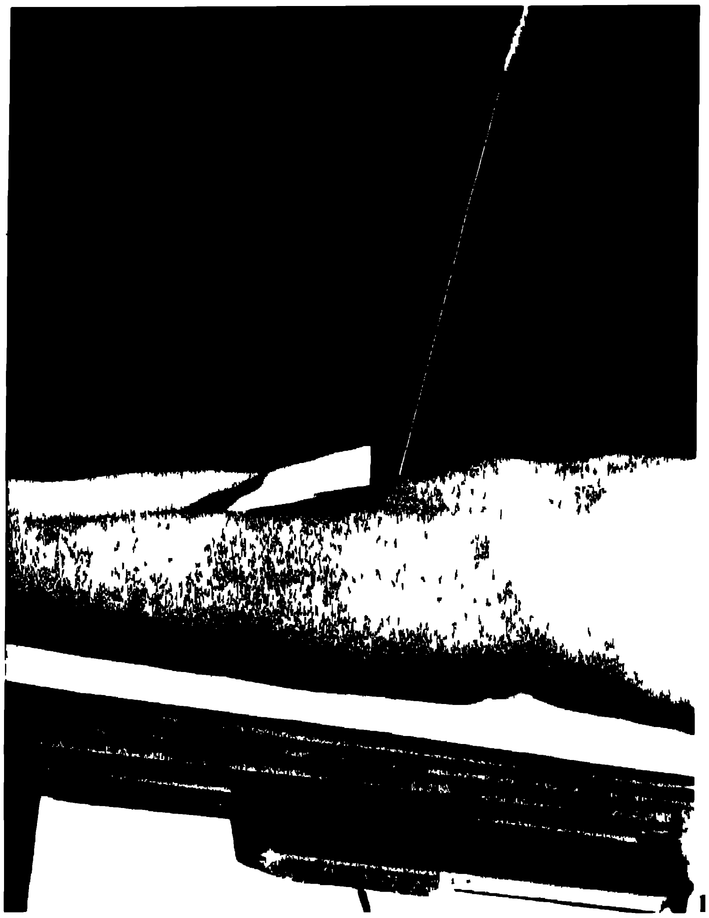
Pyeloscopy may be followed by serial radiographs of the calyces, pelves, and ureters. As the dye is excreted rapidly by normal kidneys it is difficult to select the moment of greatest effect for the exposures, but immediately the kidney is seen to be functioning freely, which should be approximately ten minutes after the intravenous injection, the region is localised to a small area under the screen, and then some form of serial apparatus is applied. Another method is to use narrow, 15 inch by 6 inch, films, four of which may be quickly exposed within a period of one minute, the kidney and full length of ureter being shown in each film. The last film is taken immediately after compression, if any, has been removed.

Illustration (**1017**) shows a series of whole plate exposures made in rapid succession to show the kidney and upper ureter.

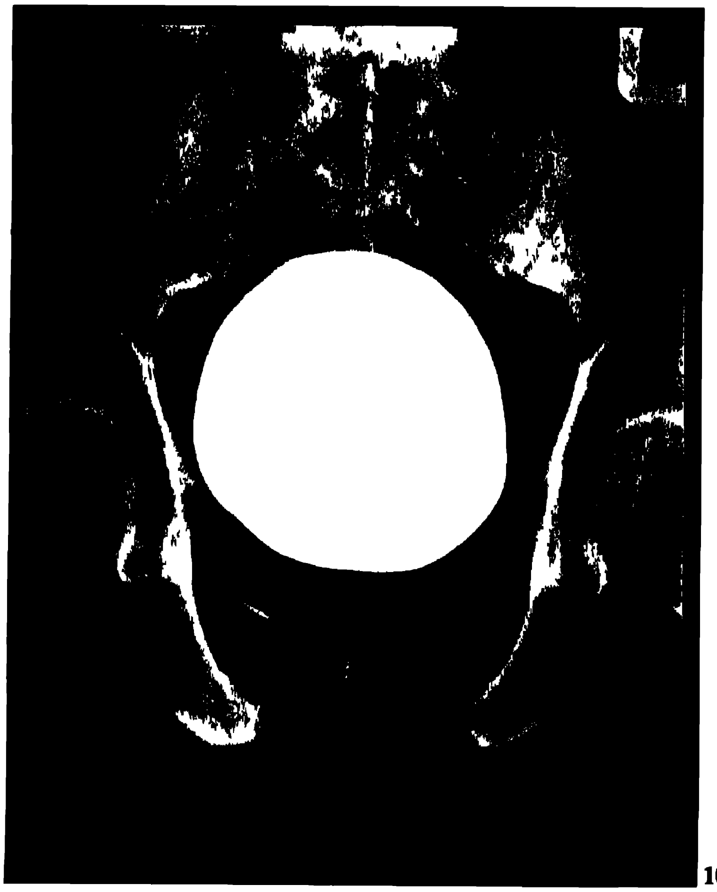
The modern quick film-changing apparatus is the most satisfactory, as by its use visualisation can be carried on during the whole period and films be taken as required.

Pyelographic examinations are sometimes carried out during pregnancy, the routine procedure being applied for both intravenous and retrograde methods. Reference should be made to Section 26 (**1065**, **1066**).


1017



1018



1019

Cystography

This term implies the radiographic examination of the bladder following an opaque injection. The opaque medium most commonly used is sodium iodide in a 10 per cent. to 20 per cent. solution, or one of the other preparations described as being used for the urinary tract, including diluted iodised oil. From 4 ounces to 6 ounces of opaque solution are generally sufficient, but larger quantities may occasionally be required. It should be noted that **(1019)** shows a bladder overfilled for normal diagnostic purposes. The preparation of the patient may include a simple enema; and the bladder is emptied and washed out immediately before the injection. If urine remains in the bladder the opaque solution will be diluted, and, in using iodised oil, the oil may collect into irregular patches.

After the injection the catheter is withdrawn before the X-ray examination is made. Films are taken in the antero-posterior and right and left oblique positions, and sometimes in the true lateral position.

These films may also be taken when the bladder is full, following a pyelographic examination.

ANTERO-POSTERIOR

The patient is supine, with the table raised at the foot to give an angle of 10 degrees to the trunk in order that the fundus of the bladder may be filled.

CENTRE in the mid-line, at the level of the anterior-superior iliac spine, with the tube angled 15 degrees toward the feet.

(1018, 1019)

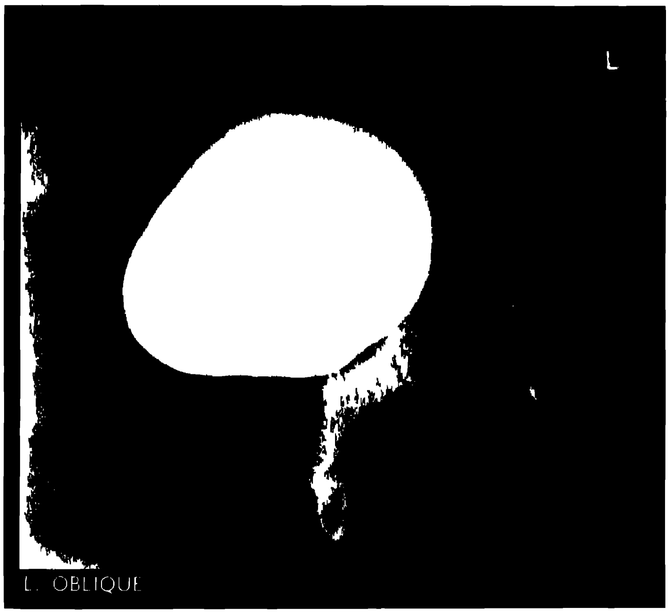
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	77	46	30″	Ilford	Tungstate	Potter-Bucky

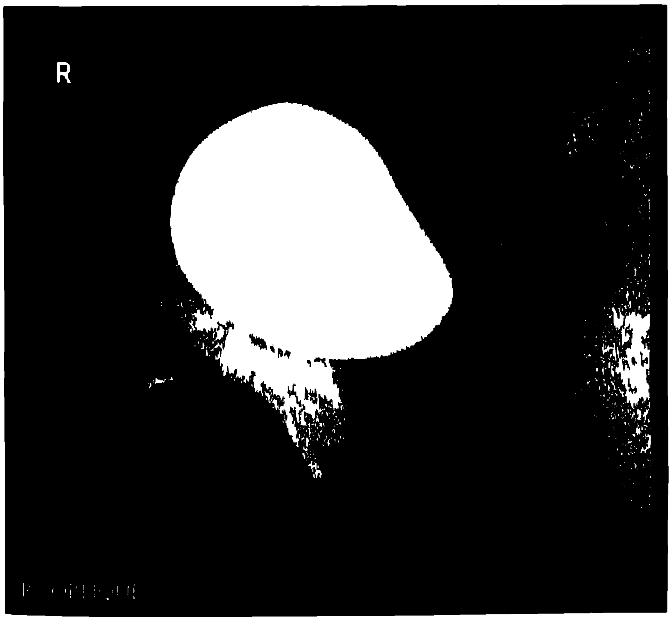
Cone to size of film, 12 × 10 in.

Reference should be made to the illustrations under **(1008, 1009)** showing the difference in the appearance of the bladder when the table is level and when it is tilted.

1020



1021



1022

Urinary Tract: Urography—Cystography

OBLIQUE

The patient is turned on to the left side for the left oblique, and on to the right side for the right oblique view. The general plane of the pelvis should be at an angle of approximately 60 degrees in relation to the table, the hip and knee joints being flexed, and the raised side supported with non-opaque pads under the pelvis and with sandbags under loin and thigh.

CENTRE to the anterior-superior iliac spine on the side remote from the table. Both sides are taken in the same way, and should be carefully marked. Stereoscopic views may be required.

(1020, 1021, 1022)

The exposure factors for the oblique views are those applied for the antero-posterior view, with an increase of 10 kilovolts.

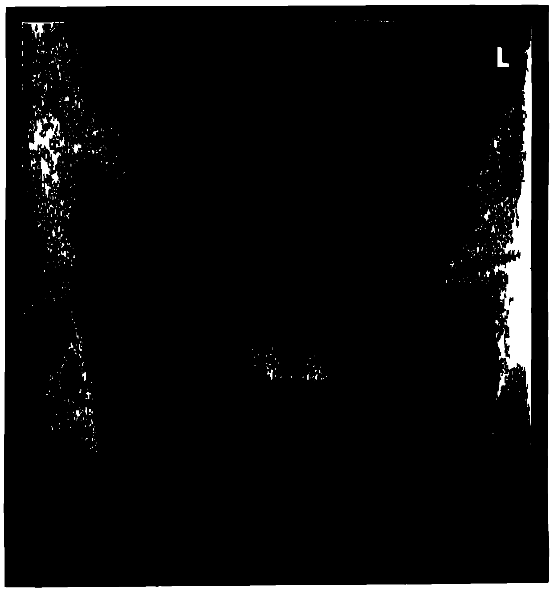
These oblique views are taken in place of a lateral view of the bladder, which is difficult to obtain owing to the great density of the pelvic structures as seen from that aspect.

LITHOTOMY POSITION

An additional view of the bladder is shown in **(1023)**. This is taken with the patient in the lithotomy position, with the tube centred over the symphysis pubis.

In the lithotomy position the patient is supine, with acute flexion at the hip joints and with the limbs supported on suitable leg rests attached to the couch.

The application of cystography to the pregnant subject is discussed on page 412.



1023

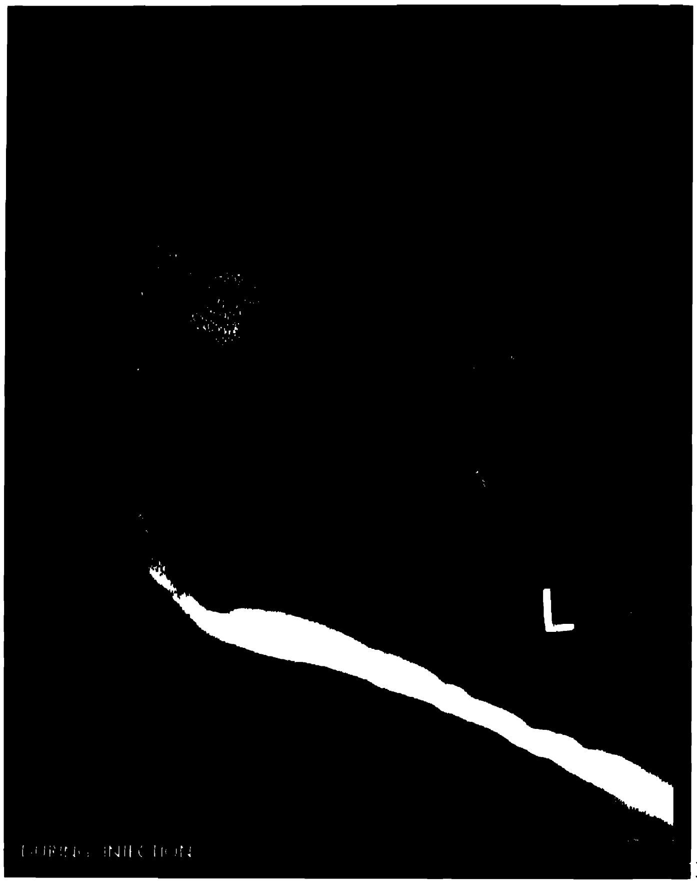
Urethrography

Urethrography is the term applied to the X-ray examination of the male urethra during an opaque injection.

Iodised oil is the most satisfactory opaque medium for this purpose, 12 cubic centimetres being prepared and warmed to body temperature.

OBLIQUE

The patient is catheterised and given a bladder wash-out: the oblique position is then assumed as for cystography **(1020)** and a rubber nosed urethral syringe, or a catheter, is introduced into the meatus of the urethra, the penis being adjusted to overlay the soft tissues of the inner aspect of the thigh. After the first 6 cubic centimetres of iodised oil have been injected, the exposure is made, the injection being continued during the exposure. Two films show the effect of injecting **(1024)**, and not injecting **(1025)**, during the exposure.



1024

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers: Ilford X-ray	mA. Secs. Ilford Developers: Blue Label	Distance	Film	Screens Ilford	Grid
70	88	53	30"	Ilford	Tungstate	Potter-Bucky

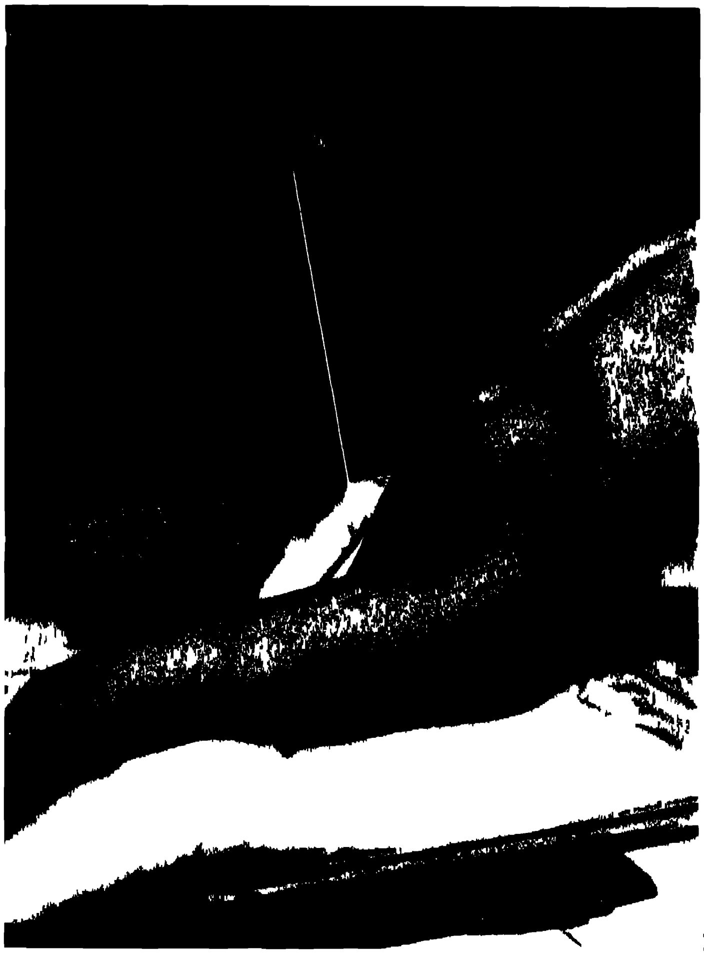
Cone to size of film, 12 × 10 in. or 10 × 8 in.

1025

Although the oblique views are most frequently employed, antero-posterior and postero-anterior views may also be included. Exposures may also be made during micturition following the injection of the opaque medium into the bladder. The two methods may well be described as ascending and descending urethrography.

Reference should be made to the anatomical diagram **(981)**, page 375.

The urethra may also be examined without injection for the presence of a stone, suitable exposure technique being applied to show the lower bladder and postero-anterior positioning adopted **(1027)**, special note being made as to the position of the penis, whether to right or left.



1026

1027

ANTERO-POSTERIOR

The patient is seated on the X-ray couch, with the back supported and with the legs separated.

CENTRE over the symphysis pubis, with the tube angled 10 degrees toward the head. The exposure is made during the injection or during micturition, according to the method employed (**1026**).

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	77	46	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in

POSTERO-ANTERIOR

The patient is placed in the prone position, with the legs separated.

CENTRE to the symphysis pubis, with the tube angled 10 degrees toward the head. The exposure is made during the injection. The exposure factors are similar to those applied for the antero-posterior view.

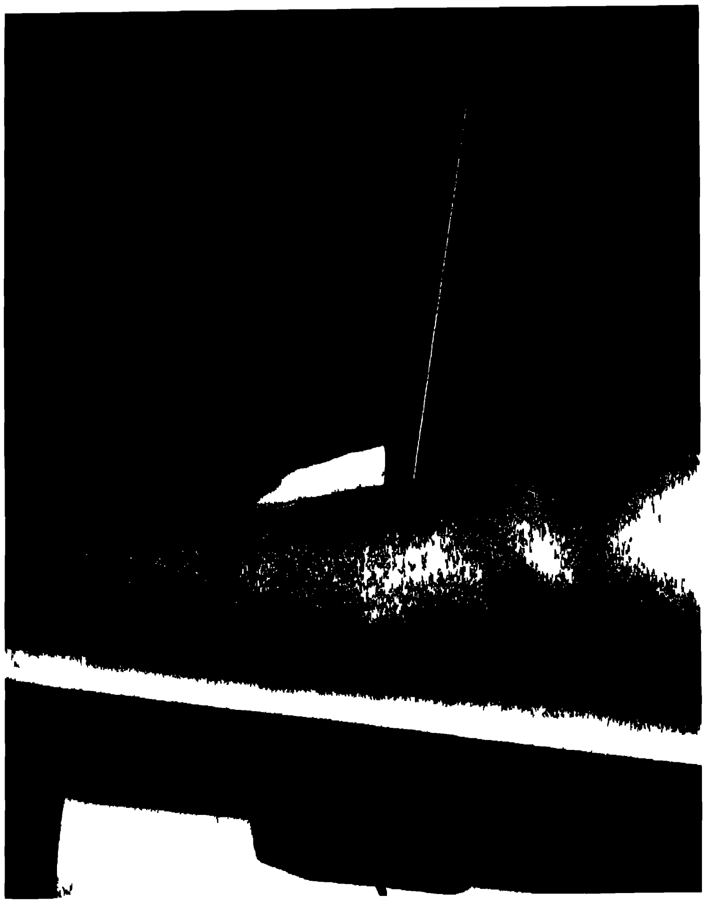
(1027)

Air Inflation

URETHRA AND BLADDER

Air is occasionally used to outline these cavities, and is introduced by catheter during a visual screen examination. Deflation is also by catheter.

Radiographs are taken precisely as for the opaque injection.



1028

1029

PROSTATE

The prostate is a small gland surrounding the commencement of the male urethra, and is situated behind and adjacent to the symphysis pubis. It is frequently examined for enlargement, new growth and for calculi.

The anatomical relations of the prostate to the urethra are so intimate that the applicability of urethrography in determining abnormal conditions of the prostate is very evident, and in such examinations the complete filling of the bladder is avoided.

Reference should be made to the anatomical diagram **(981)**, page 375.

The prostate may be examined from two aspects—antero-posterior and postero-anterior.

ANTERO-POSTERIOR

The same technique is applied as that for examination of the bladder, either

(*a*) with the foot of the table raised and the tube angled toward the feet **(1028)**: or

(*b*) with the tube straight, centring directly over the symphysis pubis **(1030)**.

This latter gives the true relationship to the symphysis of any shadows within the prostate.

EXPOSURE FACTORS

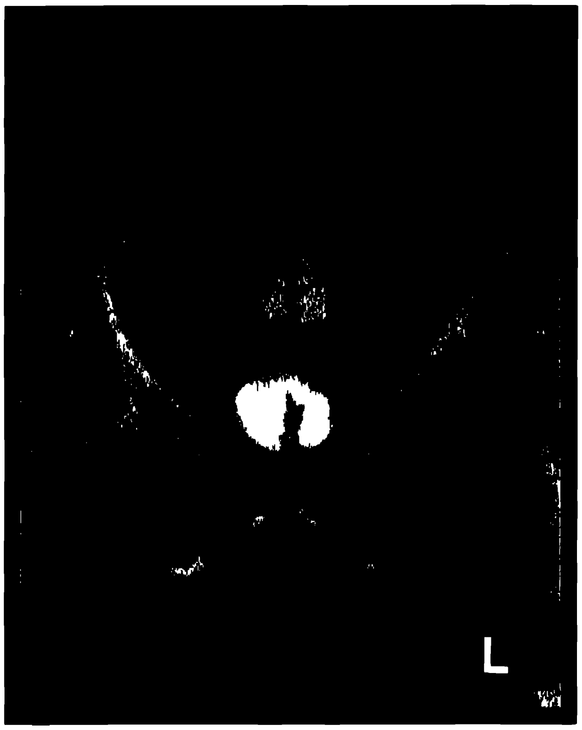
kVp	mA Secs.		Distance	Film	Screens Ilford	Grid
	Ilford X-ray	Developers Blue Label				
70	77	46	30″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 10 × 8 in.

POSTERO-ANTERIOR

This view is taken with the tube angled 10 degrees toward the head in order to project the shadows of the sacrum clear of the pubic bones **(1029)**. With the tube straight the prostate is obscured by the enlargement of the shadow of the sacrum, which, owing to increased distance between sacrum and film, is diffused over the pelvic aperture.

Prostate



1030

POSTERO-ANTERIOR—PATIENT LATERAL

An alternative method for differentiating between shadows in the prostate and in the bladder, is to turn the patient on to one side, and with the film supported vertically against the anterior aspect of the pelvis to expose for the postero-anterior view, with the tube centred horizontally, as already discussed on page 382 and illustrated in (937) page 354. The bladder should be full, when free bodies therein will fall to the lower side.

SECTION 26

Female Genital Organs

FEMALE GENITAL ORGANS

The female genital, or reproductive, system consists of the ovaries, the fallopian tubes, the uterus, the vagina, and the external genitals or vulva.

The *uterus*, a thick-walled muscular and expansile organ having a "T" shaped cavity, is situated in the mid-line of the pelvic cavity, between the bladder and the rectum. It consists of three parts, the fundus, or upper, expanded portion; the cervix, or lower, constricted portion, known also as the neck; and the body, this last being the region between fundus and cervix. In the virgin state approximately 3 inches in length and 2 inches in width, the uterus expands during pregnancy into the umbilical region, and then measures 12 inches or more in length and 9 inches to 10 inches in width. The uterus lies between the fallopian tubes, which are on either side of and below the level of the fundus, and extends in a backward and downward direction to its junction with the vagina, into which the cervix protrudes. The vagina follows a downward and forward direction (**1033, 1036**).

The *ovaries*, or reproductive glands, of which there are two, one in each side of the pelvis, vary in position and may lie anywhere from just below the postero-lateral brim of the pelvis in the ovarian fossa—to close to the side of the uterus. Their position may be indicated on the surface of the body by the mid-point of a line drawn from the upper border of the symphysis pubis to the anterior superior iliac spines (**1036**).

Each *fallopian tube* is about 4 inches long and connects the upper and lateral part of the uterus with its respective ovary, the narrow central canal being continuous with the uterine cavity; at the ovarian end the tube does not quite make contact with the ovary, but expands and opens into the peritoneal cavity, the opening being fringed with processes named fimbriæ, one of which makes contact with the ovary (**1036**).

The *vagina* encircles the lower part of the cervix and extends downward and forward to the external genitals, or vulva (**1033, 1036**). The vagina is directed upward and backward, but the uterus is anteverted and anteflexed.

GENERAL PROCEDURE

The most usual form of examination is that of the *pregnant* patient for the presence, number, age, position and condition of the fœtus. Measuration of the pelvic apertures, termed pelvimetry, and of the fœtal head, termed cephalometry, may also be undertaken.

In certain cases the *non-pregnant* patient may be examined for the patency of the fallopian tubes, this examination being termed utero-salpingography.

POSITIONING

Films may be exposed with the patient in the prone, supine, lateral and sometimes the oblique, positions, with special positioning technique for pelvimetry.

EXPOSURE CONDITIONS

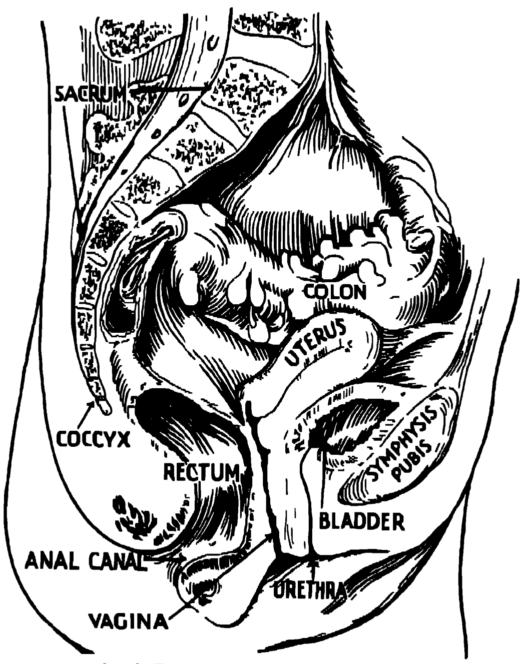
The use of intensifying screens and the grid, which may be Potter-Bucky diaphragm, sectogrid, or stationary grid, is essential.

Generally speaking, each radiologist adopts his own "standard" distance for pregnancy investigation, which distance may vary from 30 inches to 48 inches, or sometimes more. The exposure time is reduced to a minimum to secure a film showing no movement of the fœtus, movement being relatively greater when there is present an excess of amniotic fluid, a condition referred to as hydramnios. For pelvimetry high tube and transformer output is essential.

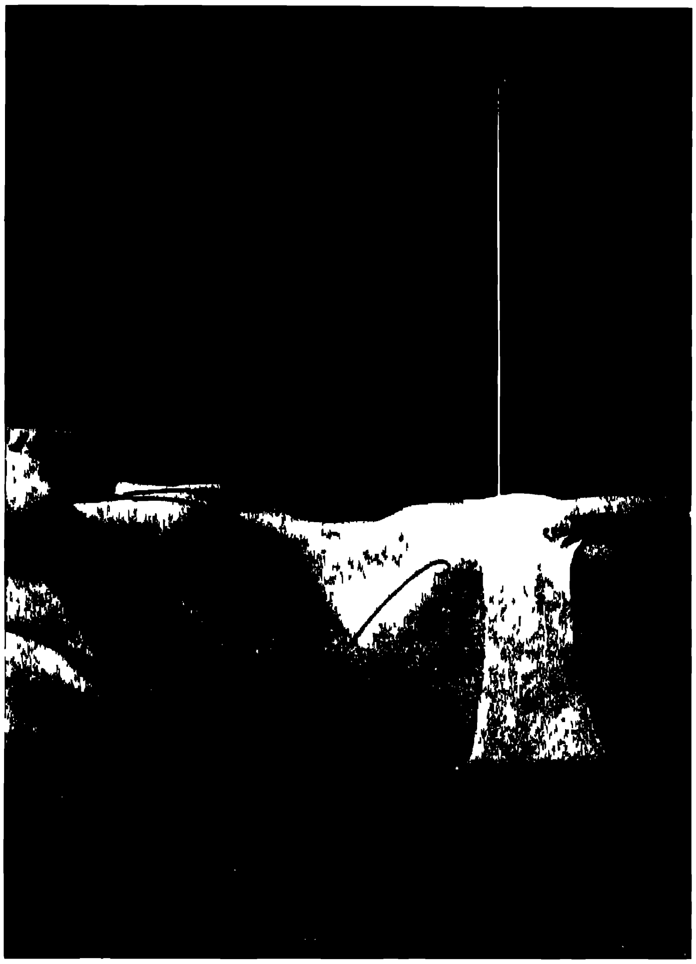
NOTE—Repeated exposures during the early stages of pregnancy may be harmful to the patient and their number should therefore be limited.

CARE OF PATIENT

Every care should be taken to avoid undue discomfort or shock to the patient; the procedure should be explained and every assistance and support given to attain and to maintain the required position.



A MEDIAN SAGITTAL SECTION THROUGH THE FEMALE PELVIS **1033**



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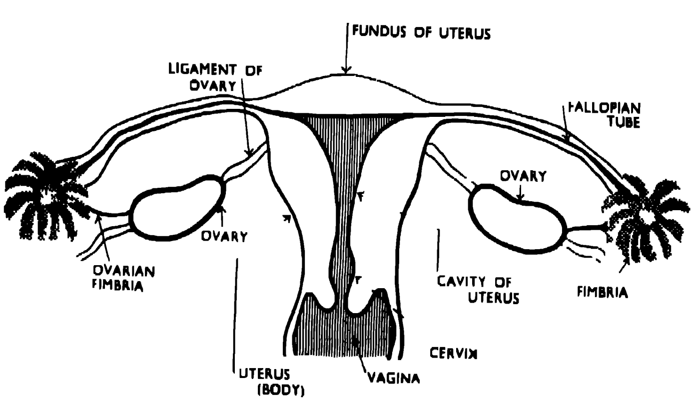
1035



1036

Female Genital Organs

Utero-Salpingography

The X-ray examination for the patency of the fallopian tubes involves the use of iodised oil as the opaque medium for injection, through the uterus, into the tubes.

The patient is usually admitted as an in-patient, and is suitably prepared to ensure that the rectum and bladder are evacuated prior to the injection. A general anæsthetic is given, and the injection may be made with the patient on the X-ray couch, when the gynæcologist is able to view, on the fluorescent screen, the filling of both uterus and fallopian tubes, or the injection may take place in the operating theatre, the cervix being plugged after the injection and the patient removed to the X-ray room for the exposure of the films. If, however, an outline of the lumen of the tubes is to be secured with certainty then the film should be taken while the last few drops of iodised oil are being injected. If there is no immediate spill into the peritoneum films may be required at 24 hours and 48 hours.

ANTERO-POSTERIOR

The patient is placed in the supine position in the middle of the Potter-Bucky couch, a small sandbag being placed under the knees for comfort.

CENTRE one inch above the upper border of the symphysis pubis. Stereoscopic views may be required.

(1034, 1035)

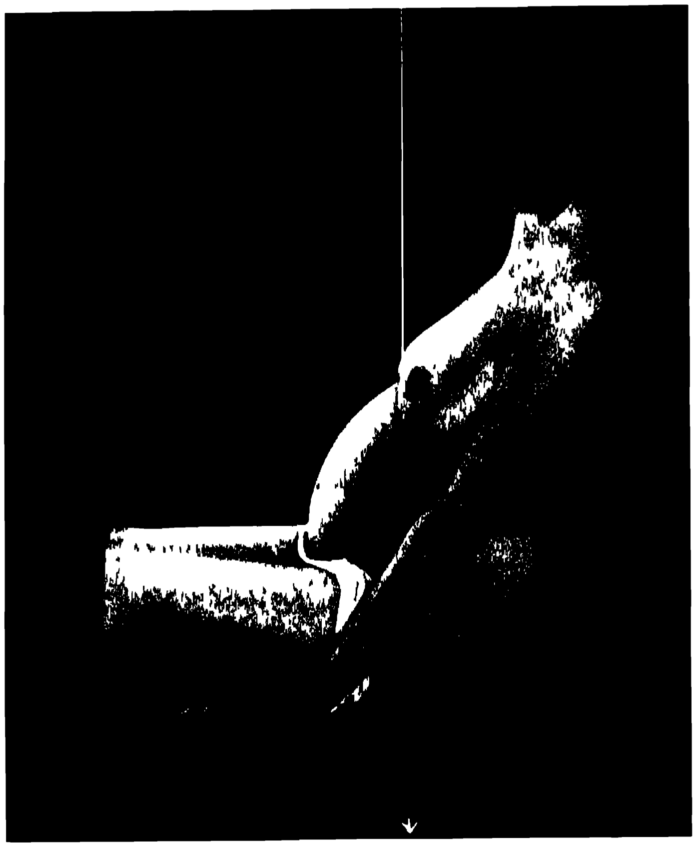
EXPOSURE FACTORS						
kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	231	140	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in. or 10 × 8 in.

Additional information regarding the *position of the uterus* may be obtained from the lateral aspect.

Pelvimetry

Various methods are in use for determining the actual dimensions of the pelvic inlet and outlet. This information is required to show whether the pelvis is large enough for the fœtus to pass through and be born in a natural manner: if the pelvis is too small or deformed a cæsarean operation may be necessary, the fœtus then being delivered by way of an incision in the abdominal and uterine wall.



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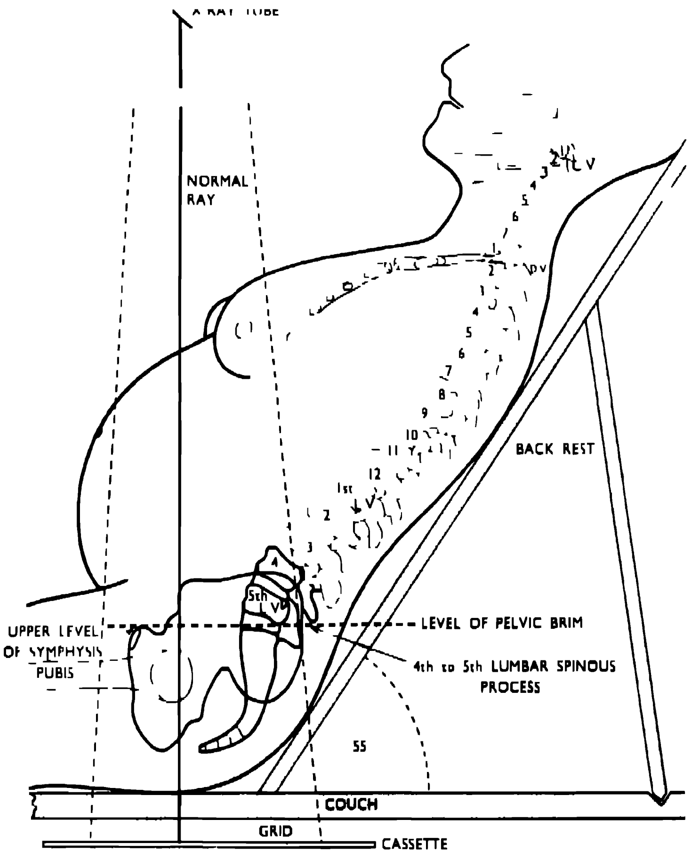


1038

Female Genital Organs: Pelvimetry

PELVIC INLET

Reasonably accurate information may be obtained by all the known methods, a limited number only being described here.

The examination may be divided into two parts:—

(*a*) positioning for the production of a plan view of the pelvic inlet:

(*b*) the calculation of the actual dimensions of the pelvic inlet from the projection-enlarged outline shown in the films.

(a) POSITIONING

The patient should be seated on the couch with her back supported at an angle of from 55 degrees to 60 degrees, the knees being raised over a small sandbag: when suitable facilities are available, however, it is preferable for the legs to be flexed over the end of the couch, with the feet resting on a stool. In this position the upper level of the symphysis pubis and the fifth lumbar spinous process should be equidistant from the couch.

CENTRE in the mid-line, between the anterior-superior iliac spines, using a small localising cone and an anode-film distance of at least 48 inches. The patient is instructed to breathe quietly during the exposure.

It is important to note the anode-film distance and either the symphysis-film, or the *anode*-symphysis, distance before the patient is removed from the couch.

(1037, 1038, 1039)

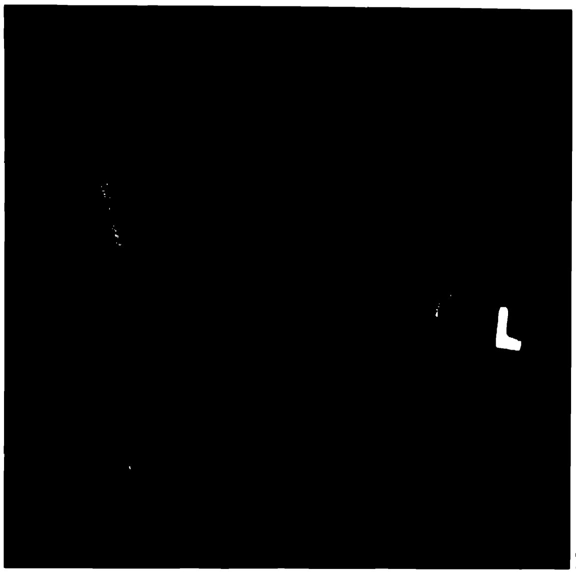
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
94	495	300	48″	Ilford	Tungstate	Potter-Bucky
84	330	200	48″	Ilford	Fluorazure	Potter-Bucky

Cone to size of film, 12 × 10 in.

The diagram **(1038)** shows the desired position of the pelvis when the patient is positioned for the exposure of the pelvimetry film.

That a correct projection of the pelvis has been produced may be confirmed, more or less, by the complete absence of the obturator foramina, which should be obscured by the pubic and ischial rami.



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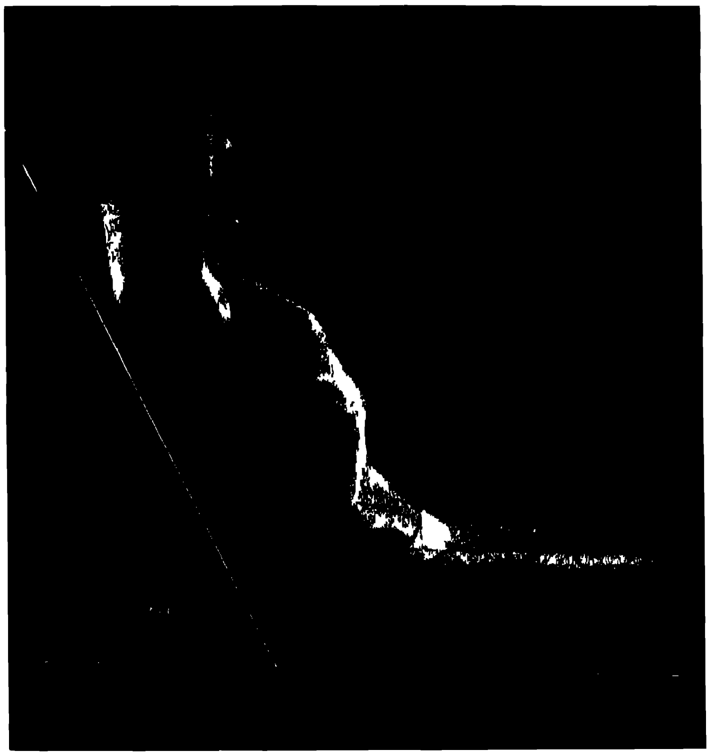
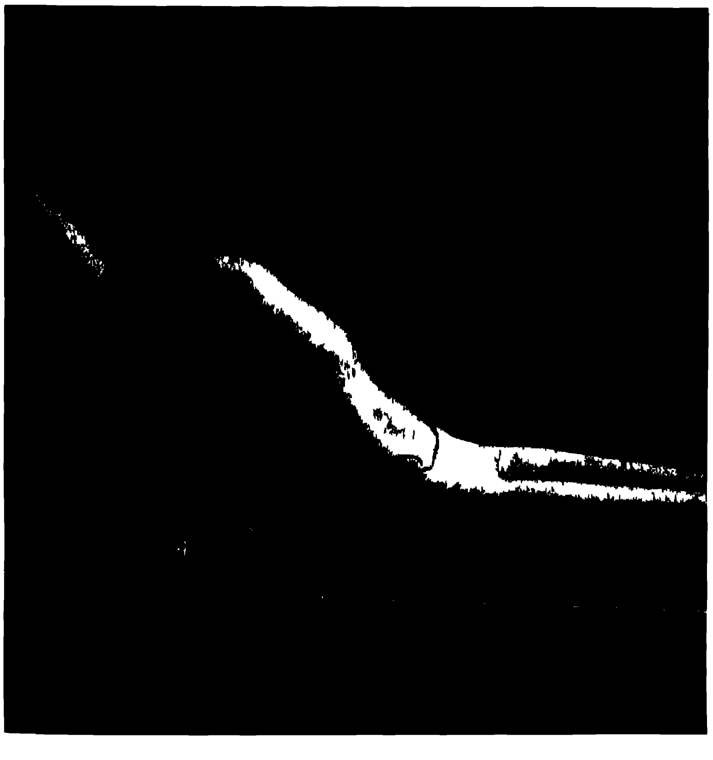

1040


1041

Female Genital Organs: Pelvimetry

(a) POSITIONING *(continued)*

For this supra-inferior projection it should be appreciated that, having established the true position of the pelvis in relation to the couch top, the eventual spine-couch angulation is not necessarily of a fixed value. Both positions **(1040)** and **(1041)** allow the pelvic brim to be parallel to the film, although there is a difference of 20 degrees in the spine-film angle; the position similar to **(1040)**, however, applied to the pregnant subject **(1037)**, usually permits also of satisfactory projection of the fœtal head **(1039)**. When this is required, therefore, the spine angulation generally adopted is from 55 degrees to 60 degrees.

There is now obtainable a specially constructed pelvimetry "table". This is in the form of a large-surface chair, the seat of which, at a height to allow the average patient to rest the feet on the floor, is formed by the grid, the back of the chair being shaped at an angle of between 55 degrees and 60 degrees. This pelvimetry chair is usually fitted with a sectogrid, the central axle of which always appears in the film **(1045)**. The pelvic aperture centre is adjusted to the centre of the grid, and the tube adjusted to both.

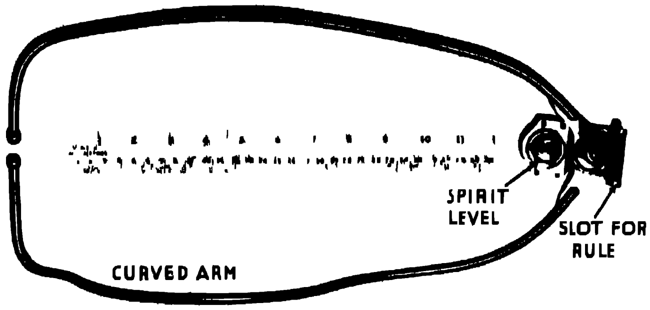
The sectogrid replaces the Potter-Bucky diaphragm, and is so constructed that continuous movement about the central axle is obtained. A free grid, however, such as was in use before the advent of the Potter-Bucky couch, may easily be incorporated in a pelvimetry chair.

When the sectogrid, with its central shadow, is not used, a plumb line with a small lead bob may be allowed to hang from the tube to within three inches of the patient during the exposure, this serving to show the position of the central ray in the resulting film **(1042)**. During advanced pregnancy the centring point may be well above the level of the umbilicus **(1037, 1038)**.

The difference in density between the posterior aspect of the pelvis and the symphysis pubis may be adjusted by shading the symphysis during the exposure. The pictorial result is thus improved; but actual measurements are usually equally well obtained from an unshaded film.

The shader consists of a piece of lead 3 millimetres thick, 6 inches long, and approximately 12 inches wide, fastened between two pieces of three-ply wood and mounted on a handle about 18 inches in length for convenient manipulation, the shading edge being curved to the shape of the abdomen and being applied above the level of the umbilicus. The shading period occupies approximately half of the total exposure time, the shader being kept in motion during its application. The result is an evenly exposed film as shown in **(1045)**, in this instance a positive reproduction.

1042



1043

1044

Female Genital Organs: Pelvimetry

PELVIMETRY CALIPERS

To ensure that the correct position of the pelvis is obtained, that is, with the pelvic brim parallel to the film, a pair of special calipers may be applied from the side. One arm of this accessory, curved to fit over the thigh, rests with its extremity on the upper border of the symphysis pubis, the extremity of the other arm being placed at the level of the space between the fourth and fifth lumbar spinous processes. The relative level of these two positions is checked by a small universal spirit level fitted at the angle of the caliper arms **(1043)**; and by means of a celluloid rule fitting vertically into a slot at the angle of the calipers, with its foot resting on the film, the symphysis-film measurement may be made accurately and without any difficulty **(1044)**.

The back support, which may be an ordinary bed-rest made to fit on to the X-ray couch, should allow free access to the lumbo-sacral region when the patient is in position. In **(1044)** the angle of the back-rest is indicated by a white line.

(b) CALCULATION OF SIZE BY FORMULA

The pelvic inlet measurements required are:—

(1) the true conjugate or antero-posterior, extending from the lumbo-sacral angle to the deep surface of the symphysis pubis:

(2) transverse diameter, extending from side to side mid-points of the brim:

(3) and (4) oblique right and left, extending from the ilio-pubic eminence on the one side to the brim at the sacro-iliac articulation of the other side **(1044a)**.

A pair of dividers and a finely calibrated ruler should be used to take these diameters from the enlarged film image, then by applying the following formula the actual diameters of the pelvis may be obtained:—

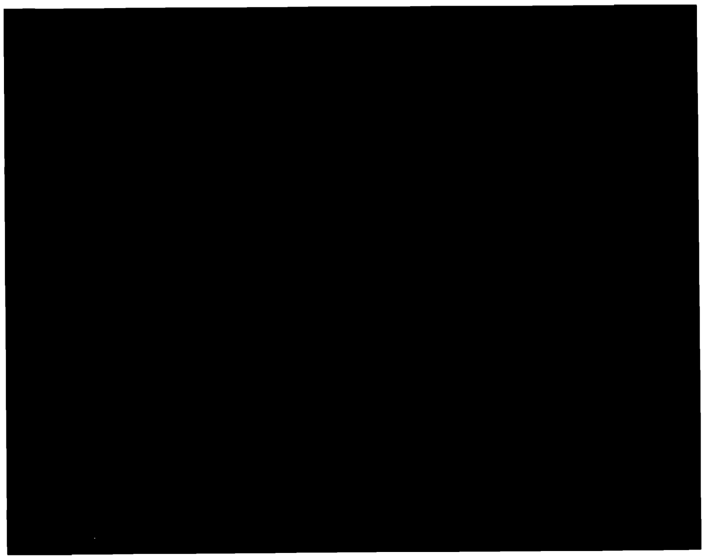
Actual pelvic measurement=

$$\frac{\text{Film diameter measurement} \times \text{anode-symphysis distance}}{\text{anode-film distance.}}$$

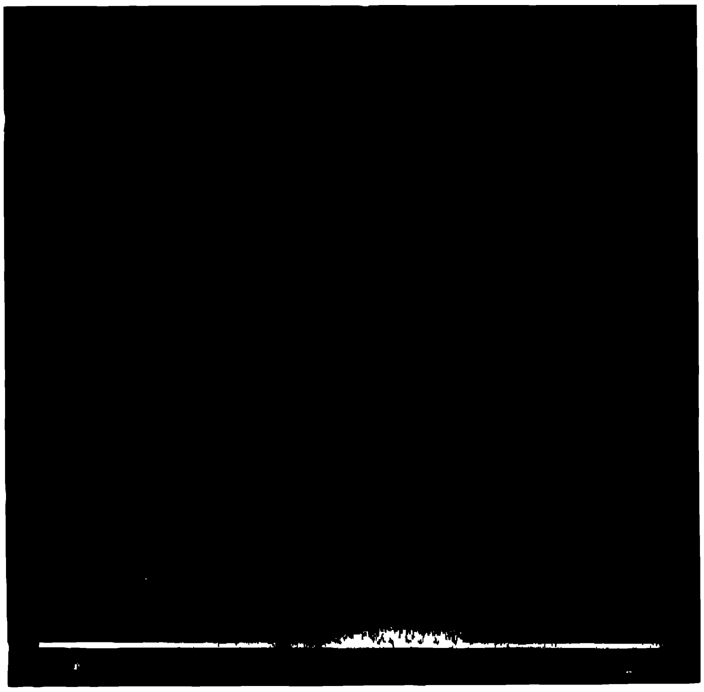
For example, when the film diameter measurement is 6 inches, the anode-symphysis distance 35 inches, and the anode-film distance 40 inches, then the actual pelvic diameter is:—

$$\frac{6 \text{ inches} \times 35 \text{ inches}}{40 \text{ inches}} = 5\tfrac{1}{4} \text{ inches.}$$

The calculation is applied to each diameter. This method, however, is not widely used, the mechanical reproduction of the dimensions described in the following paragraphs being generally preferred.



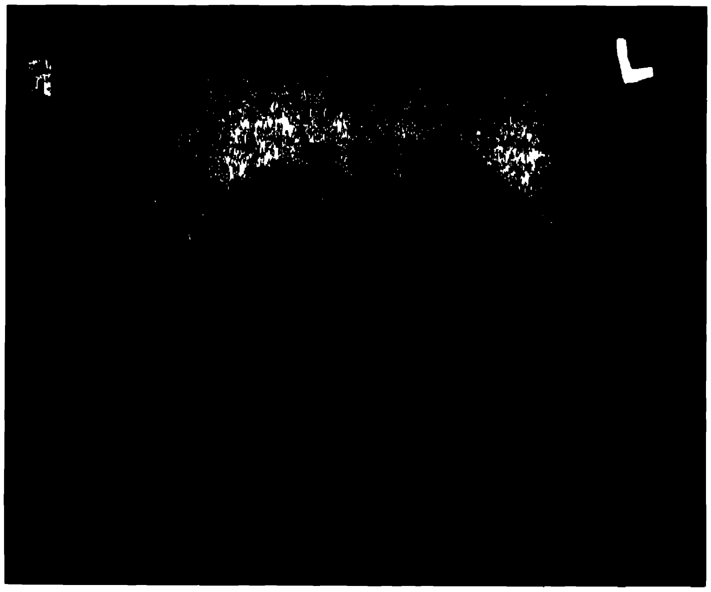
1044a



1045

PUBIC MEASUREMENT 5¼ inches
TRUE CONJUGATE 5 inches
TRANSVERSE 5¼ inches
RIGHT OBLIQUE 5¼ inches
LEFT OBLIQUE 5¼ inches

Age 31 Height 5 feet 5 inches
5 months pregnant
Single fœtus



1046

(b) CALCULATION OF SIZE *(continued)*

BY PERFORATED RULER

During, or apart from, the taking of the film it is possible to reproduce from an object of known dimensions the same degree of distortion as occurs in the projection of the pelvic brim. This may be done by placing at the level of the pelvic brim a metal ruler having holes drilled to indicate half-inch intervals, the ruler being included in the radiograph of the patient; or by taking a separate film of the ruler placed at the individual patient's symphysis-film distance, using the same anode-film distance. By either method the enlarged illustration of the ruler is used to measure directly the various diameters of the pelvis (**1045**). As the symphysis-film measurement varies from 4¾ inches to 6 inches, a stock series of prints may be prepared from films of the ruler exposed at each quarter-inch between, and at, these levels.

The use of the perforated ruler is recommended, in conjunction with a 55-degree back-rest angle, with the legs flexed over the end of the couch; the shading of the symphysis pubis during the exposure; the use of the rotating sectogrid; an anode-film distance of at least 54 inches, and, therefore, high tube and transformer rating (**1045**).

BY PERFORATED LEAD SHEET

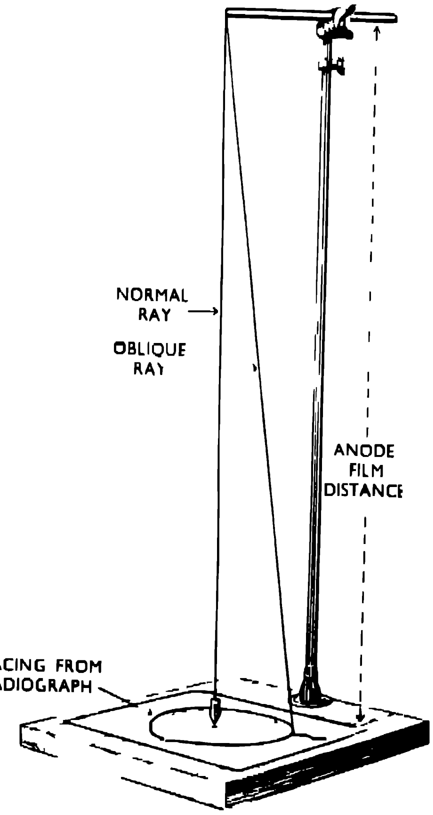
As an alternative to the ruler, a sheet of lead foil of dimensions 12 inches by 10 inches, with small holes pierced one centimetre apart in both directions, may be employed. When the patient has been radiographed and removed from the couch, the film is left in position and the metal sheet placed at the patient's symphysis-film distance and a light exposure made *on the previously exposed film.* From the resulting film bearing the two images a direct reading is made by counting the number of holes, each representing one centimetre, across the antero-posterior and transverse diameters (**1046**). For the right and left oblique measurements a tracing of the enlarged centimetre spaces should be placed across the oblique diameters of the pelvis. This method permits of the positioning of the patient in the semi-recumbent position, the tilting of the pelvic brim being determined by measurements of the distance from symphysis pubis to couch and from the space between the fourth and fifth lumbar spinous process to couch, and the perforated lead sheet then being tilted accordingly.

The use of the perforated lead sheet is recommended also for the purpose of obtaining the true conjugate measurement of the pelvis from the lateral aspect. The patient should be supine, with the X-ray beam directed horizontally toward the film and the Potter-Bucky diaphragm or stationary grid placed vertically against the lateral aspect of the pelvis.

(b) CALCULATION OF SIZE (*continued*)

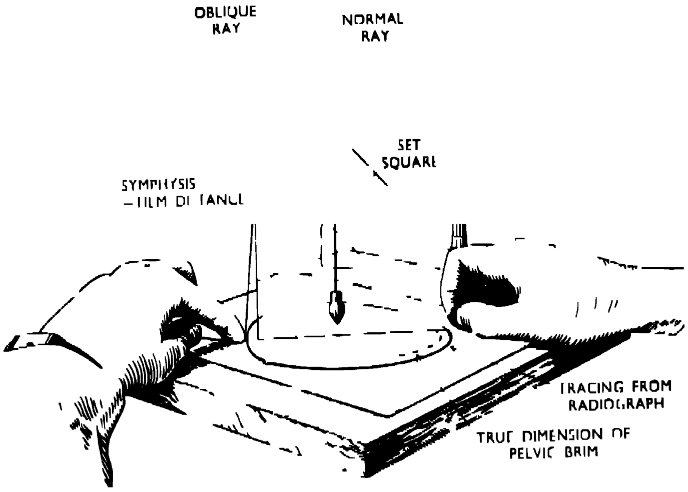
BY PROJECTION TRACING

By another method a complete tracing of the pelvic brim in actual size is obtained. A tracing is made from the pelvic film and is fastened by means of a pin on the plumb bob spot to a conveniently sized base table, on which is erected a miniature gallows of simple construction, this enabling the relative positions of tube, film and direction of central and oblique rays to be reproduced **(1047)**. The horizontal arm is adjusted above the base table at the anode-film distance applied in taking the film so that a plumb bob suspended from it falls to the pin at the plumb bob spot. The central ray is thus represented.



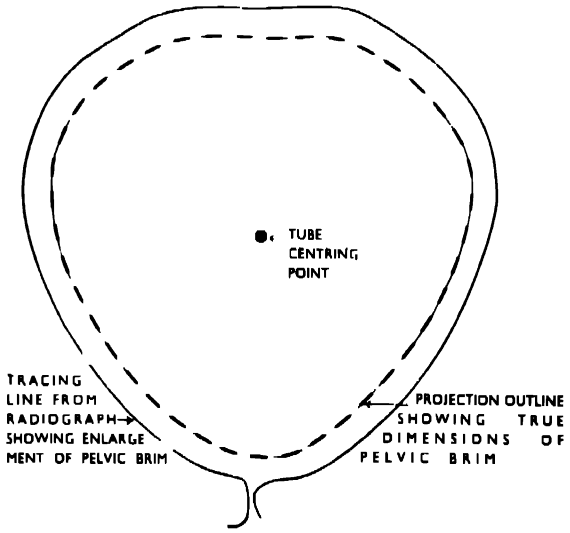
1047

From the same point of suspension a second, and free, line is dropped to the base table. This line, representing the oblique ray, may conveniently be of elastic so that it may remain taut when its foot follows the pelvic outline on the tracing as the latter is rotated round the pin. The actual outline of the pelvis is represented by the path described by the foot of the perpendicular dropped to the base table from the point of intersection of this oblique ray line and the horizontal plane at the height at which the symphysis was above the film at the time of the actual exposure. A set-square, having a weighted foot, and graduated especially for measurement of the symphysis level, is used to show the vertical height at its point of intersection with the representative oblique ray **(1048)**. It should be noted that it is not essential for the plumb bob to be *central* to the pelvic aperture, but it should be *within* the aperture.



1048

A diagram shows the finished tracing with pelvic diameters indicated **(1049)**. It should be noted that in **(1048)** the special weighted set-square indicator has been replaced by an ordinary celluloid set-square.



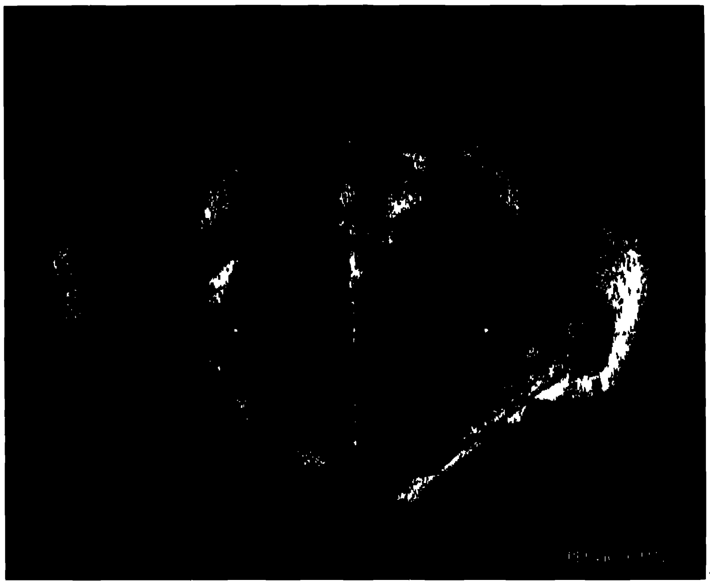
1049

ACTUAL MEASUREMENTS

TRUE CONJUGATE	5	INCHES
TRANSVERSE . .	5¼	INCHES
RIGHT OBLIQUE	5¼	INCHES
LEFT OBLIQUE	5¼	INCHES

BY STEREOMETRY

A stereometric method giving accurate measurements of pelvic inlet and outlet has been formulated, but it is not, however, in general use in this country.



1049a

Female Genital Organs: Pelvimetry

PELVIC OUTLET

Pelvimetry is chiefly concerned with the measuration of the pelvic *inlet*, and a radiographic demonstration of the pelvic *outlet* is rarely required. Its demonstration, however, is of interest.

The antero-posterior diameter extending from the lower border of the symphysis pubis to the distal extremity of the coccyx **(1051a)** is demonstrated in the lateral view of the pelvis. The transverse diameter extending between the posterior surfaces of the ischial bones **(1049a)**, shown in **(1050, 1051)** is described in the following text. Actual measurements of the two diameters may be ascertained by applying the formula given on page 402.

The patient is seated on the couch, with the knees separated and flexed over the couch end and the feet resting on a stool. The trunk is then flexed forward from the hip joints until the head is between the knees, or as near to this position as comfort permits, with the arms extended toward the feet.

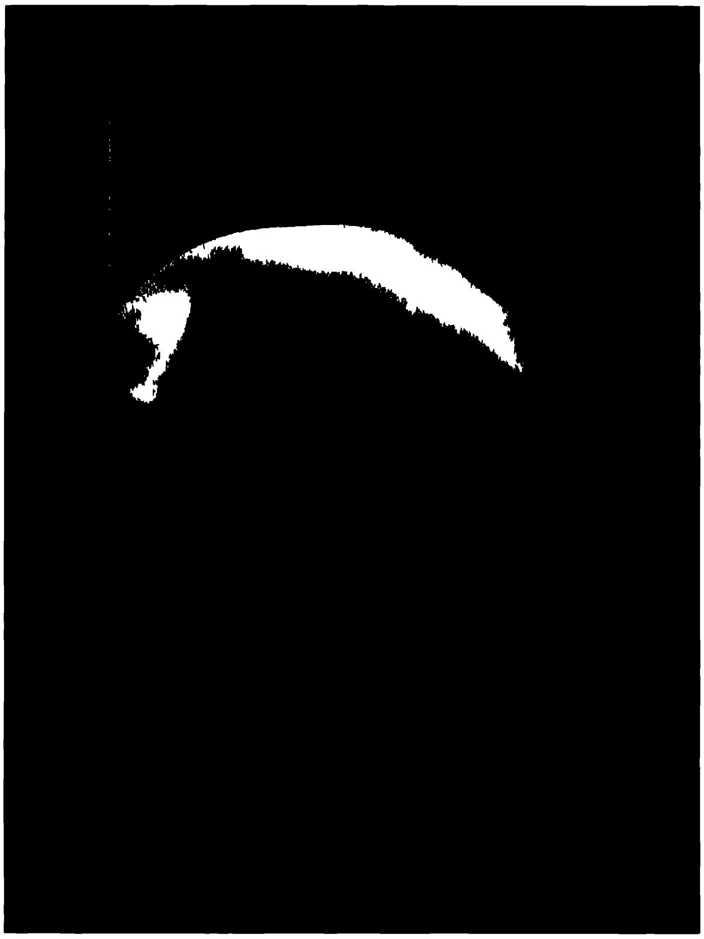
CENTRE over the mid-sacral region.

It is necessary to shade the pubic and ischial bones for 75 per cent. of the total exposure time required for the remainder of the pelvis **(1050, 1051)**.

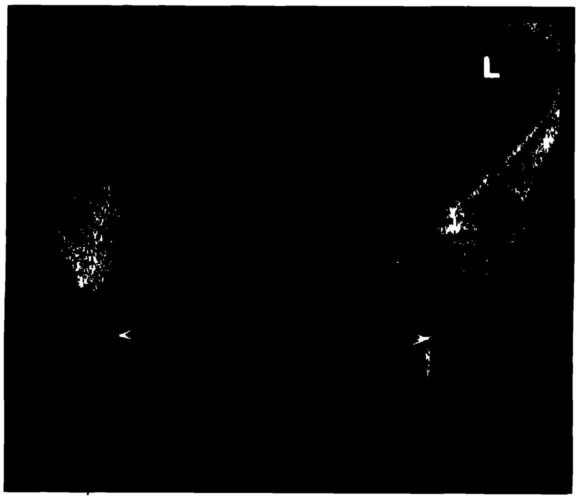
EXPOSURE FACTORS

kVp.	mA. Secs. Ilford Developers X-ray	mA. Secs. Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
80	198	120	36″	Ilford	Tungstate	Stationary
80	264	160	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in.



1050

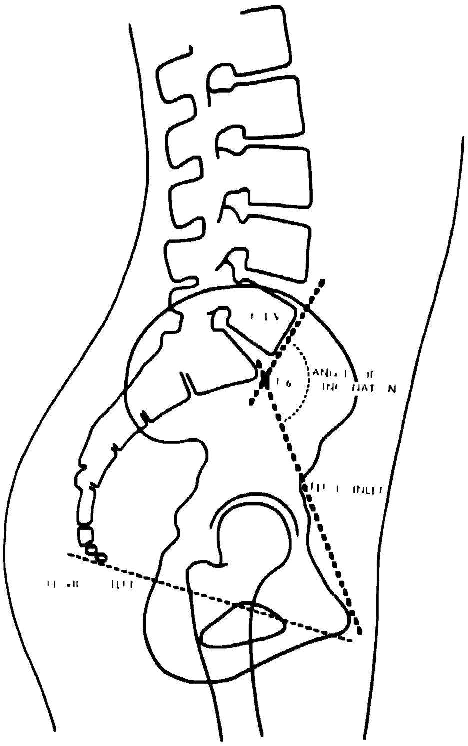


1051

Female Genital Organs: Pelvimetry

ANGLE OF PELVIC INCLINATION

The angle formed by the plane of the brim of the pelvis and the anterior margin of the fifth lumbar vertebral body is referred to as the angle of pelvic inclination **(1051a)**.



1051a

This angle, which varies with posture and from subject to subject, may be demonstrated radiographically in lateral exposures embracing the lumbo-sacral region and pelvis. The plane of the brim of the pelvis may be shown by a line drawn from the superior border of the symphysis pubis to the lumbo-sacral angle (or promontory), the angle formed at the point of its intersection by a line drawn parallel to the anterior margin of the fifth lumbar vertebral body is the angle of pelvic inclination—abnormal angles may be of considerable obstetric importance.

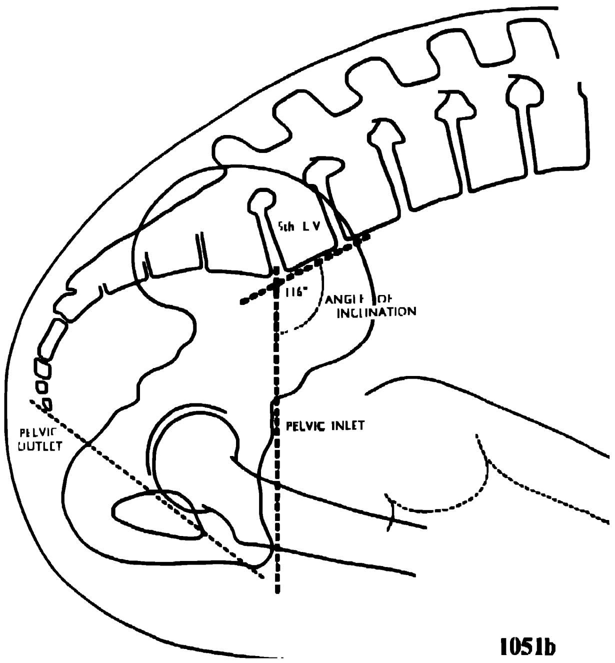
Postural variations depend on the trunk and limbs being straight **(1051a)** or flexed **(1051b)**; the angle of inclination is reduced in the latter condition, the reduction being less considerable in full term subjects, when the degree of flexion is necessarily limited.

Tracing diagrams from radiographs exposed in the two positions indicate the variation in the angle of pelvic inclination due to posture with the patient horizontal, (a) straight 126 degrees and (b) flexed 116 degrees. Reference should be made to the lumbo-sacral region, page 143, diagram **(402a)**, in which two tracing diagrams, (a) and (b), taken from radiographs of the one patient, straight and flexed, respectively, have been placed one over the other in order to indicate the degree of movement occurring in the lumbo-sacral and lumbar region. (Reference should be made also to radiographs **(402, 403)** and diagram **(372)**).

The sacral curve, affecting as it does the capacity of the pelvis, may also be of considerable obstetric importance. Two variations of the curve **(a)**, **(b)** are indicated in diagram **(1051c)**.

It will be appreciated that production of satisfactory radiographs of the pelvis from the lateral aspect is essential.

NOTE—Antero-posterior diameters of both the *inlet* and the *outlet* of the pelvis are shown on diagrams **(1051a, 1051b)**.



1051b

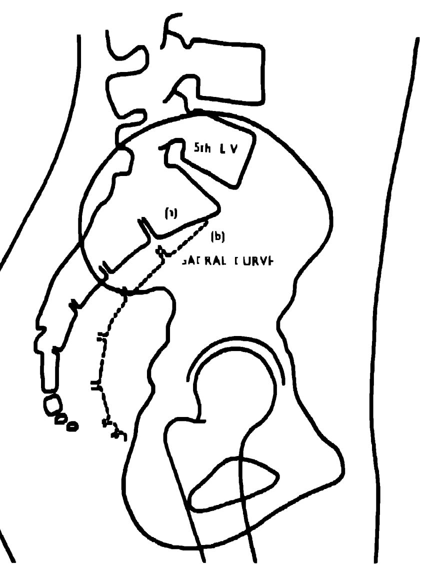
Fœtal Head Measuration

Approximate fœtal head measurement, of one or more diameters, may be obtained in certain cases by the method applied in determining the pelvic measurements from the projected shadow, as for pelvimetry, but complicating factors are, however, involved and the resulting measurements are, therefore, less accurate than for pelvimetry. This process is termed cephalometry.

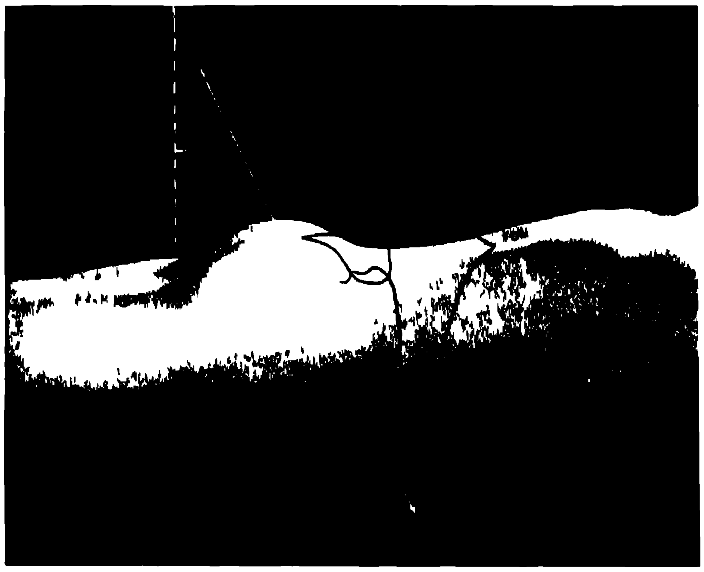
A pelvicephalometer allows calculations to be made as to pelvic and fœtal head dimensions from films taken in the antero-posterior and lateral positions, both films being exposed with the patient supine.

Early Pregnancy

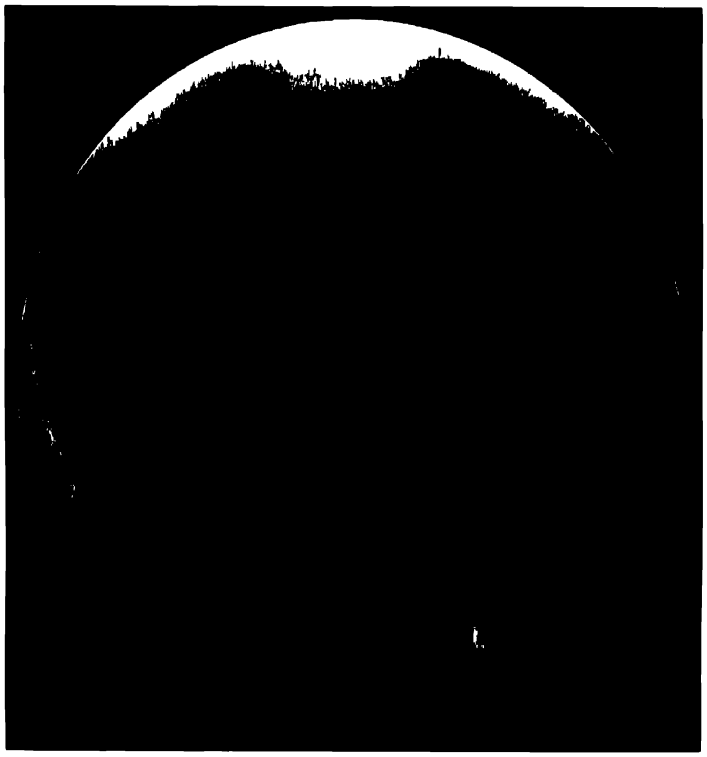
In the early stages of pregnancy—from 3 months to 4 months—it is not always possible to show the fœtus, more than one exposure having sometimes to be made before obtaining a film in which it can be identified. At this stage the fœtus is low down in the pelvis and is best shown with the patient in the prone position.



1051c



1052



1053

Female Genital Organs: Early Pregnancy

POSTERO-ANTERIOR

The patient is placed in the prone position, in the centre of the Potter-Bucky table, with support under the ankles.

CENTRE below the coccyx, with the tube angled approximately 15 degrees toward the head to enable the sacral bones to be projected above the level of the fœtus. The exposure should be made on expiration (**1052, 1053**).

EXPOSURE FACTORS						
kVp	mA Secs Ilford Developers X-ray	mA Secs Ilford Developers Blue Label	Distance	Film	Screens Ilford	Grid
65	98	60	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 12 × 10 in or 10 × 8 in

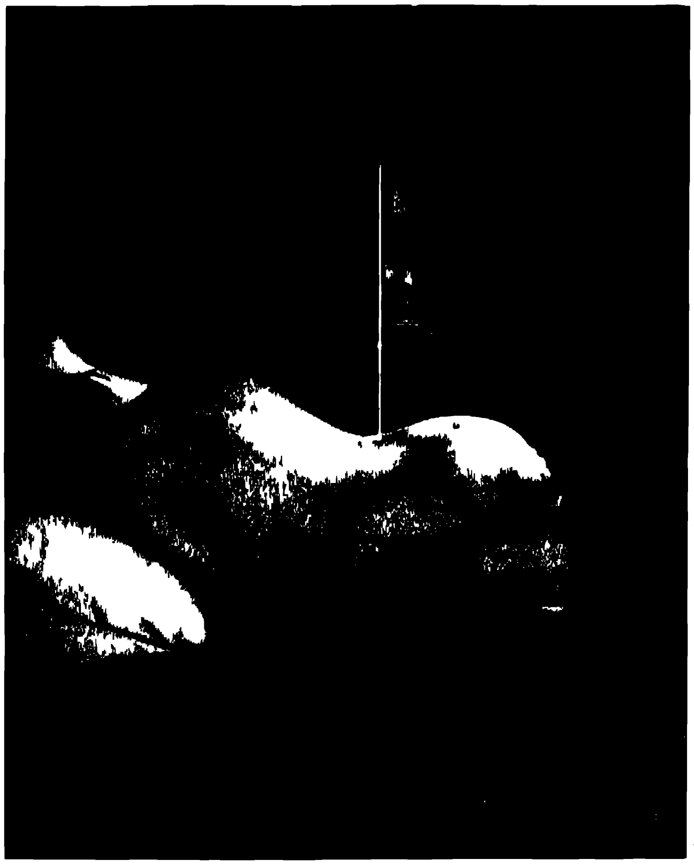
Should the fœtus not be detected in the initial film another exposure should be made at a lower kilovoltage, and an antero-posterior view may also be taken as for the urinary bladder.

The radiograph shows a 3 months to 4 months old fœtus lying transversely at the level, radiographically, of the sacro-coccygeal articulation (**1053**). In the original radiograph the fœtal skeleton is clearly defined.

Advanced Pregnancy

During the later stages of pregnancy the fœtus may be clearly shown in all its detail. The films may be taken with the patient in either the prone or supine position, this depending on the tolerance of the individual and the apparatus available: in some cases both the antero-posterior and the postero-anterior views are necessary to demonstrate the point under investigation.

The lateral view is usually included unless the investigation is only to confirm the presence of a fœtus shown in an earlier exposure, or to show the position, whether vertex or breech presentation, "vertex" indicating that the head is directed downward, and "breech" that the fœtal pelvis is toward the maternal pelvis. For all other investigations at least two views are required, one being a lateral. These will be for the investigation of the exact position, age and any abnormality of fœtus, and also for multiplicity, all of these features being difficult to identify in a single film. Particularly good definition is essential when specified information is required, such as in the case of a breech presentation (**1060, 1061**), when it is important to know whether the arms and legs of the fœtus are flexed or extended; or when the age of the fœtus is to be determined by the stage of development of the bones and



1054

ossifying centres of the epiphyses, or for the detection of certain fœtal abnormalities.

POSTERO-ANTERIOR

The patient is carefully assisted on to the X-ray couch and placed centrally, in the prone position, with a wool bag support under chest and pelvis, which aids will steady the patient in position and prevent undue pressure on the abdomen. The head is turned to one side, the hands are clasped under the upper chest, and a sandbag is placed under the ankles to raise the toes from uncomfortable pressure on the couch. When suitable equipment is available this view may be taken with the patient supine **(1056)**, using an *undercouch* tube and an *overcouch* Potter-Bucky diaphragm or stationary grid.

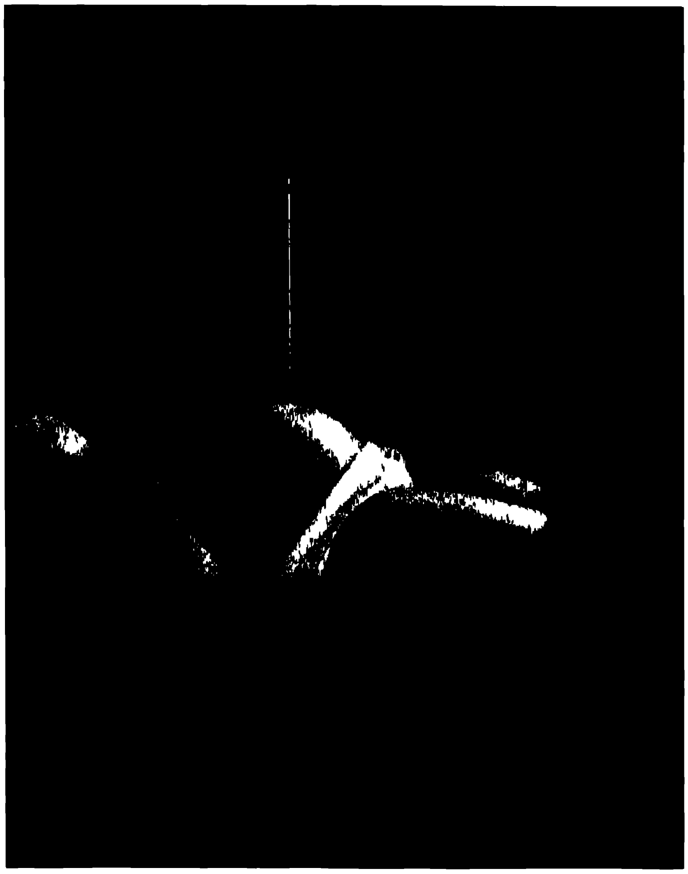
CENTRE to the apex of the abdominal curve, at the approximate level of the fourth lumbar vertebra, with the film placed to include the upper border of the symphysis pubis. The exposure is made on expiration. In this position a particularly well defined outline of the fœtal head is obtained, as it is near to the film and there is no intervention of maternal bone structures **(1054, 1055)**.

Exposure factors are given on page 411

The right lateral view of this patient is included under **(1055a)**.

1055

1055a



1056

ANTERO-POSTERIOR

The patient is placed in the supine position, central to the Potter-Bucky couch, with the hands clasped over the upper chest, and the knees raised over a small sand-bag to prevent undue strain in this position.

CENTRE to the apex of the abdominal curve, at the approximate level of the fourth lumbar vertebra. The exposure is made on expiration, the film being placed so as to include the upper border of the symphysis pubis.

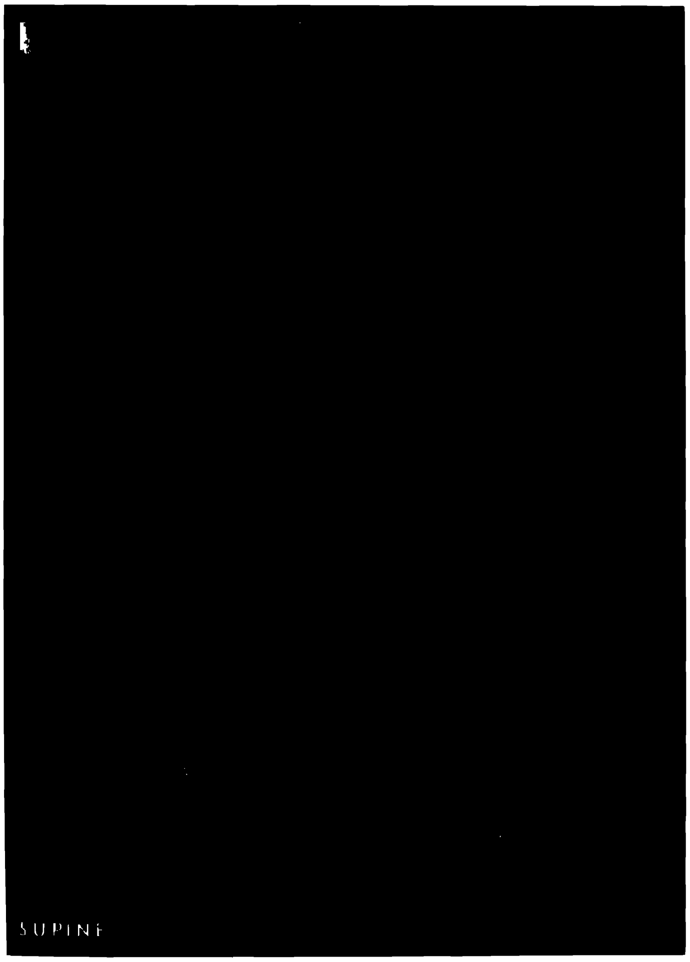
This view gives a less clearly defined image of the fœtal head, which may be more easily obscured by maternal bone structure than in position **(1054)**.

(1056, 1057)

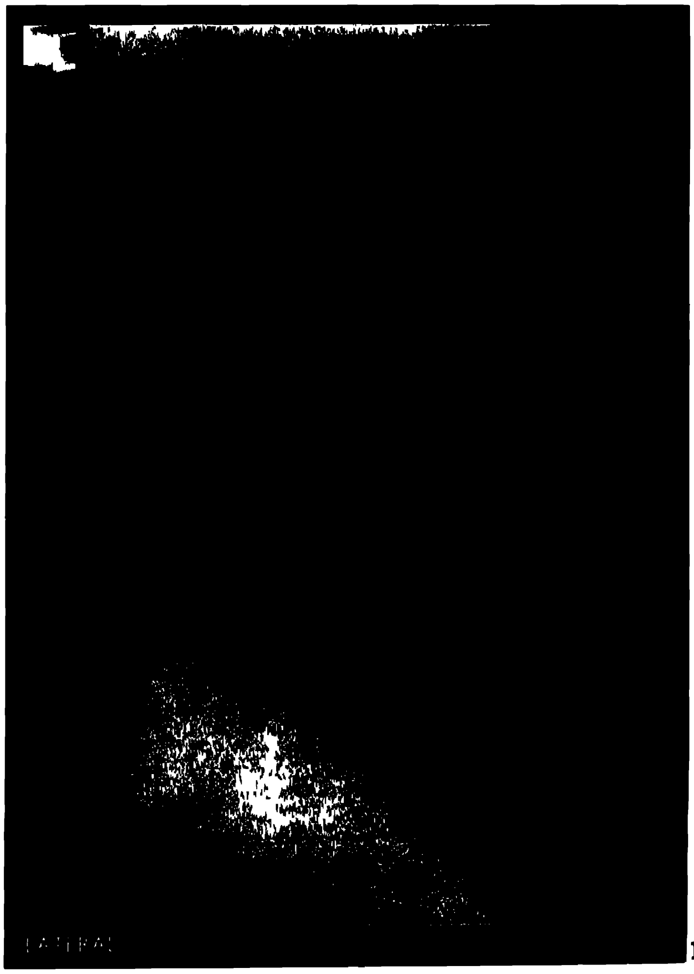
Exposure factors are given on page 411.

The left lateral view of this patient is included under **(1058)**.

The four radiographs **(1055, 1055a, 1057** and **1058)**, showing a vertex presentation, were all taken of the same patient. The appearance in the postero-anterior and antero-posterior views should be noted, as also the difference between the right and left lateral views which, though taken at short intervals, indicate considerable movement of the fœtus in the interim.



1057



1058

1059

LATERAL

The patient is turned on to the side which she finds to be the more comfortable, and is supported in that position with sandbags under the raised arm and leg, and with a wool pad between hip and couch.

It should be noted, however, that when suitable facilities are available the lateral exposure should be made without moving the patient from the supine position (1056), grid and film cassette being placed vertically against the patient and projection being made horizontally.

CENTRE to the apex of the abdominal curve, midway between lumbar spine and anterior margin of the abdomen.

The film should be placed to include the upper border of the symphysis pubis. Exposure should be made on expiration. (1059, 1060)

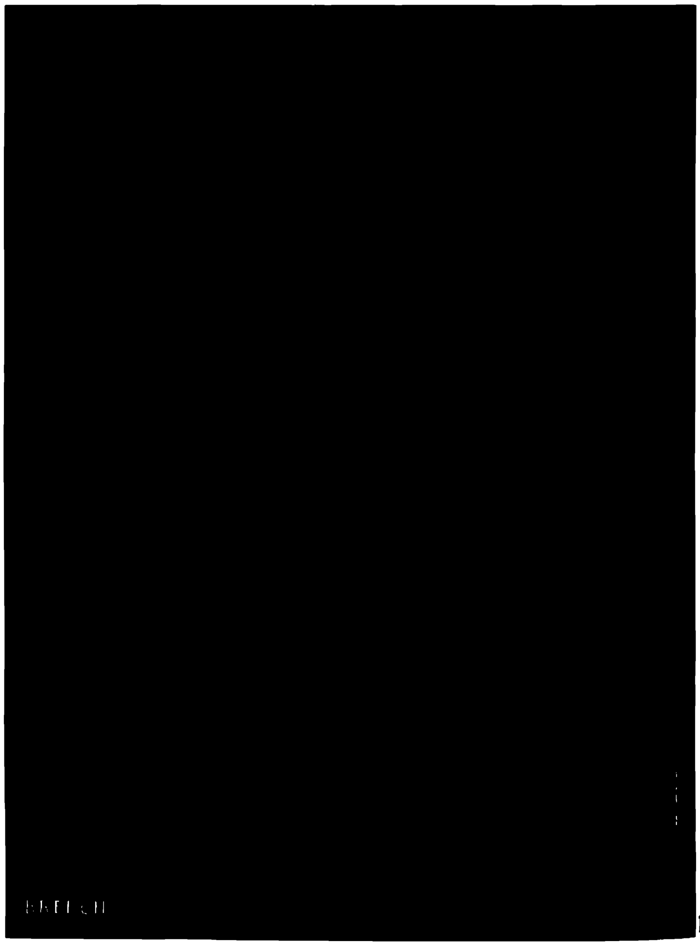
Exposure factors are given on page 411.

Two films are included, postero-anterior and lateral, showing a breech presentation (1060, 1061).

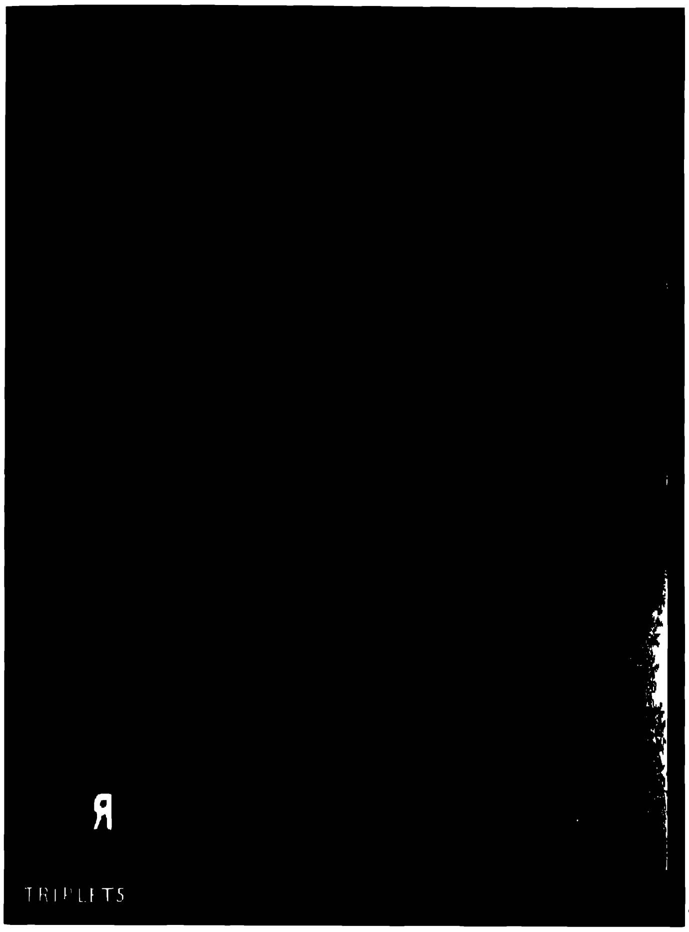
MULTIPLICITY

Films are included to show multiplicity, both triplets and twins. In these cases special care should be taken to identify both heads and spines in two or more views. (1062, 1063, 1064)

1060



1061



1062

Female Genital Organs: Advanced Pregnancy

EXPOSURE FACTORS

The following are the exposure factors required for the general examination of full term patients as shown on pages 408, 409 and 410.

POSTERO-ANTERIOR AND ANTERO-POSTERIOR

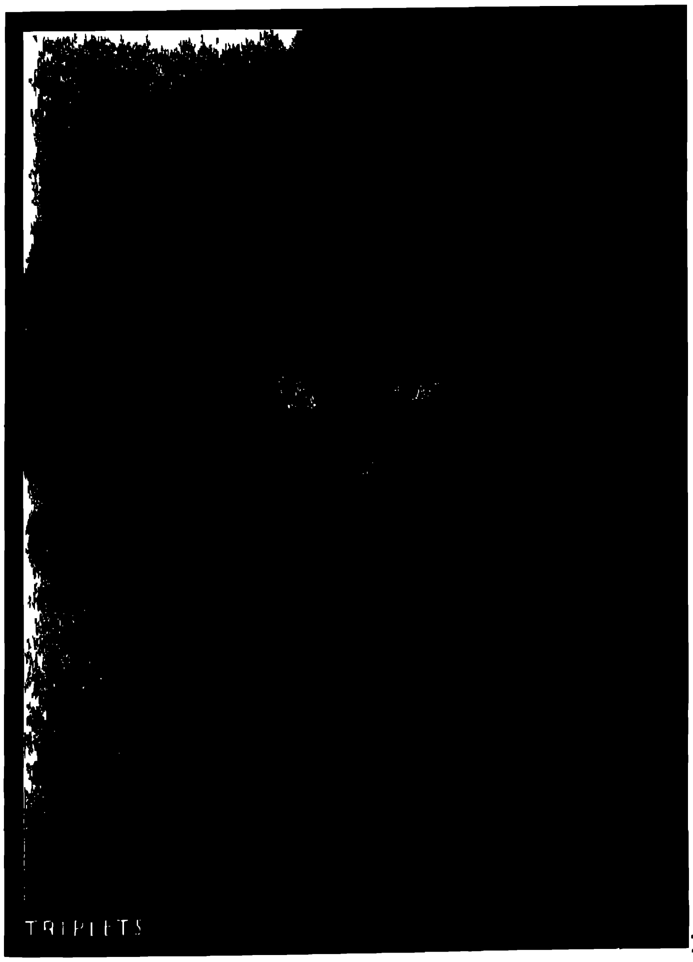
EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
84	198	120	36″	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 15 × 12 in or 17 × 14 in

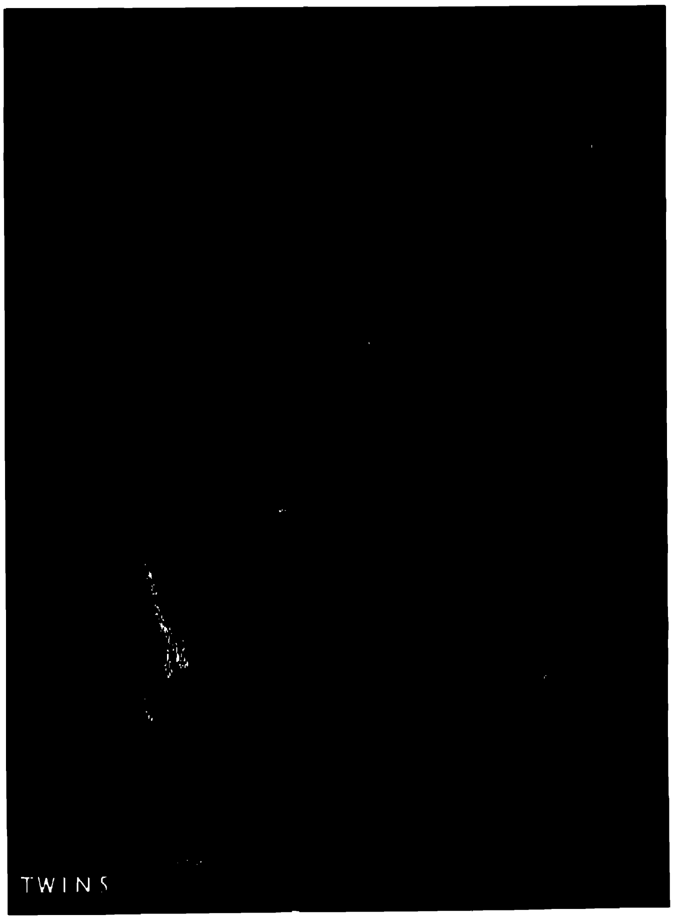
LATERAL

EXPOSURE FACTORS						
	mA Secs					
kVp	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
84	247	150	36″	Ilford	Tungstate	Potter-Bucky

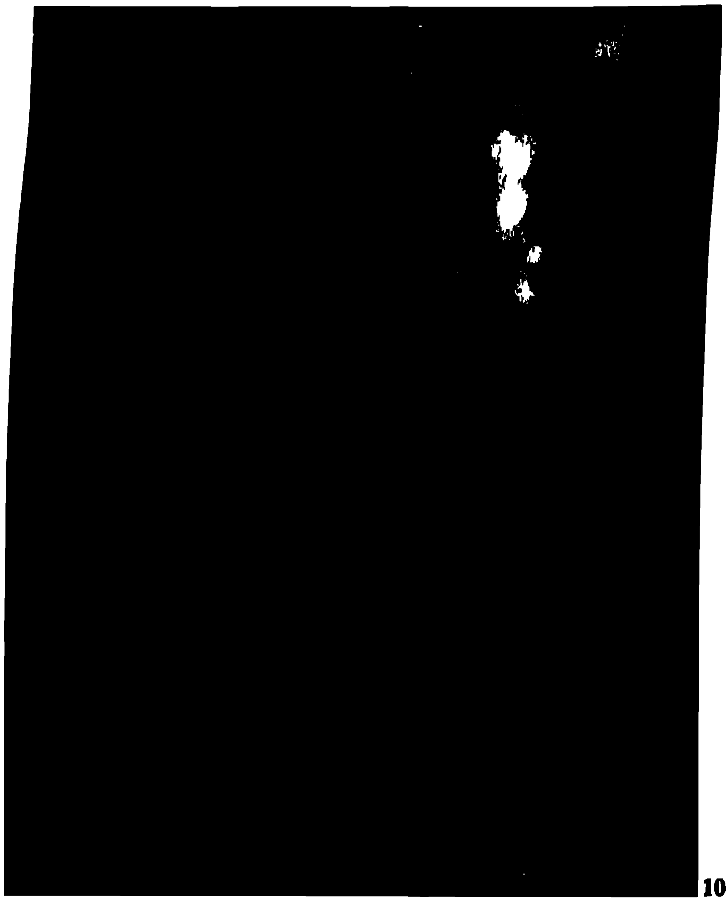
Cone to size of film, 15 × 12 in or 17 × 14 in



1063

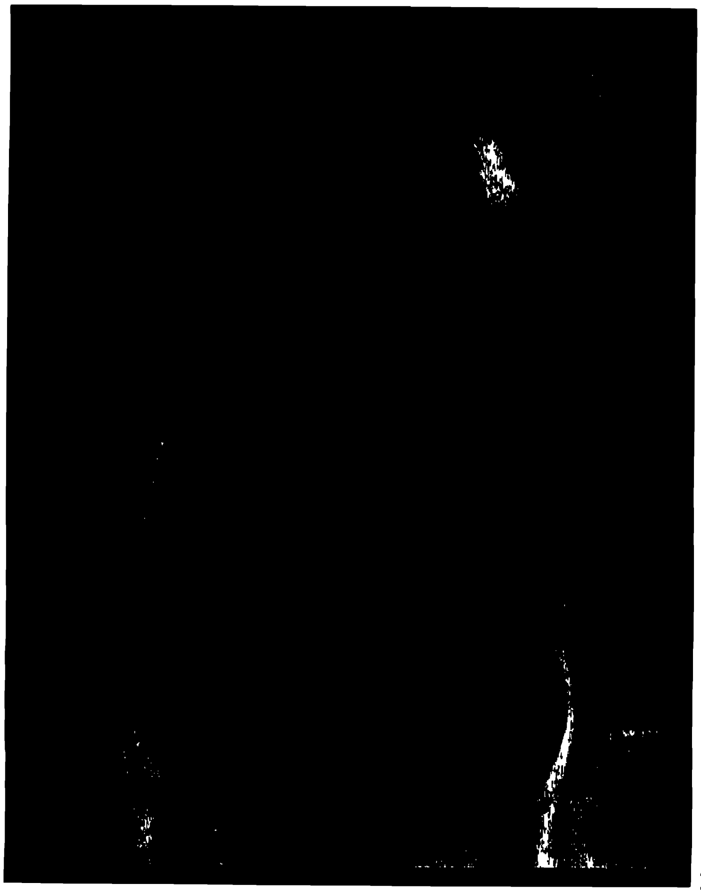


1064



1065

INTRAVENOUS PYELOGRAM



1066

RETROGRADE PYELOGRAM

Urography in Pregnancy

During pregnancy the renal tract may be examined by intravenous (1065) or retrograde (1066) pyelography, the procedure discussed on pages 384-388 being observed.

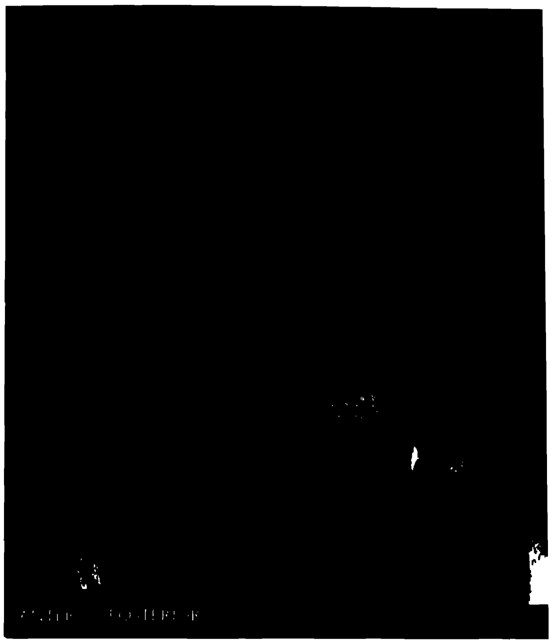
CYSTOGRAPHY

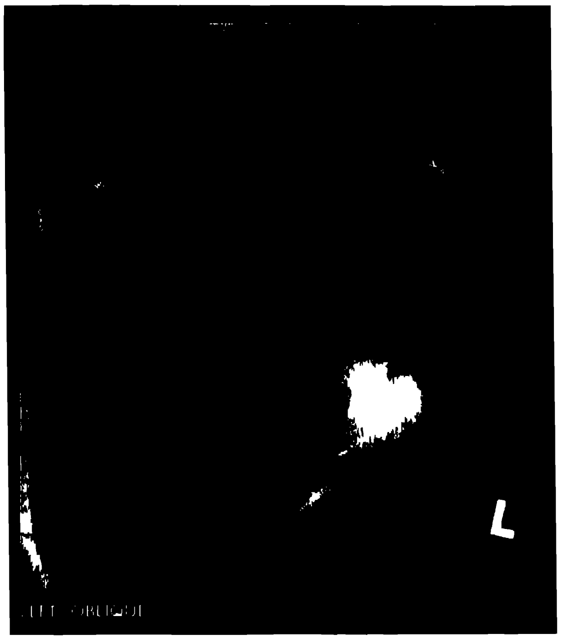
Cystography may also be applied for the purpose of showing the relative positions of the fœtal head and the urinary bladder, as the condition of placenta prævia (placenta before fœtus) may be indicated by the appearance of an unusually wide space between the head of the fœtus and the bladder.

For the investigation of this condition a preliminary control film is followed by an injection into the bladder of from 2 ounces to 3 ounces of a 12 per cent. solution of sodium iodide, and films are taken with the patient in the supine and right and left oblique positions, gentle pressure being applied to the fœtus in the direction of the symphysis pubis during the exposure. Further details of positioning technique will be found on pages 390 and 391.

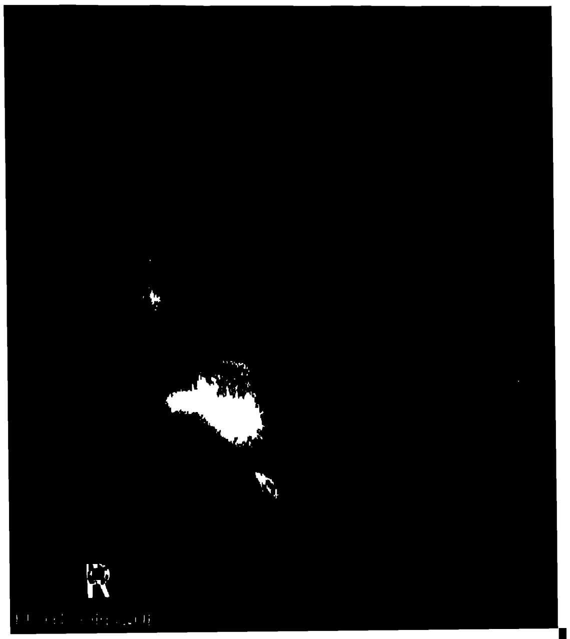
CENTRE immediately over the upper border of the symphysis pubis.

Two series of films are shown (1067, 1068, 1069) and (1070, 1071, 1072). It should be noted, however, that neither of these is a complete series.

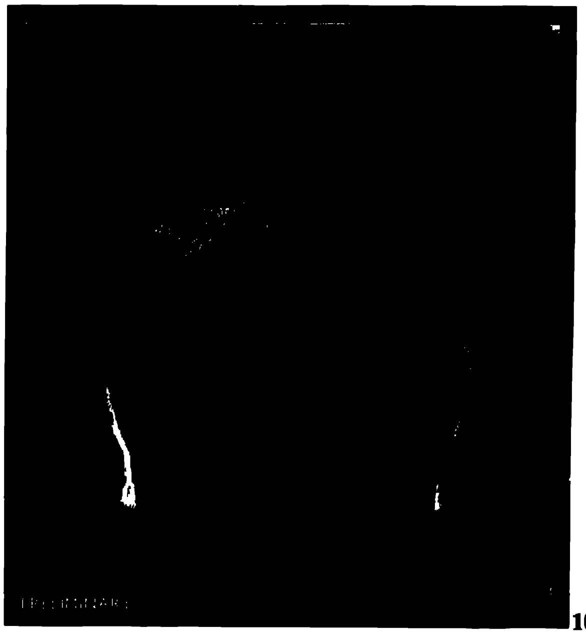

1067

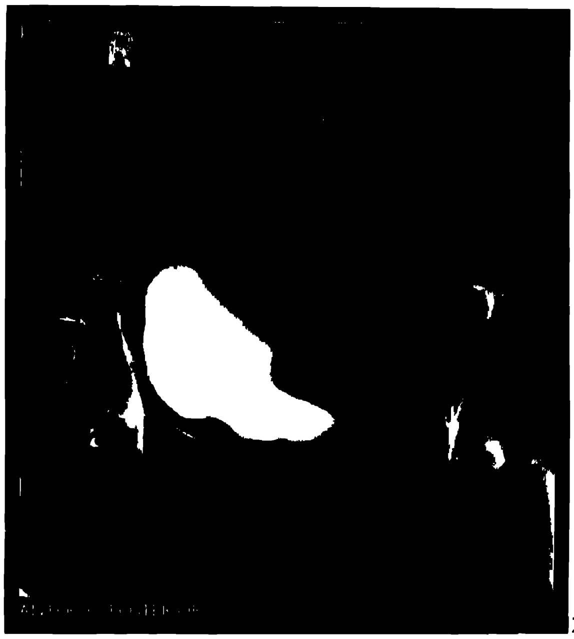


1068

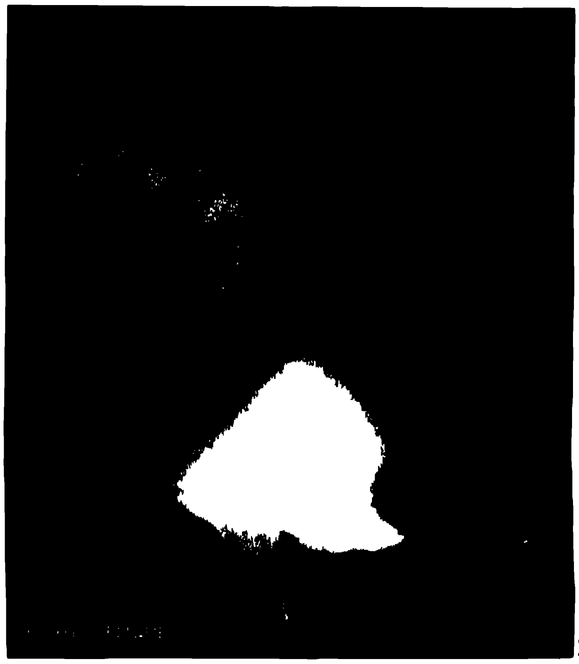


1069


1070



1071


1072

Female Genital Organs

1072a

Amniography

This term indicates the taking of a radiograph following the replacement of some of the amniotic fluid surrounding the fœtus by a contrast medium, such as Uroselectan B, the examination being made in the hope of showing the relative positions of the placenta and the fœtus **(1072a)**.

As previously stated the amniotic fluid is sometimes present in excessive quantity, when the condition is referred to as *hydramnios*; and on account of the added opacity it is usually necessary to increase the radiographic exposure by from 25 per cent. to 50 per cent.

1073

Post-Mortem Fœtus

It is sometimes necessary to undertake post-mortem examination of the fœtus, antero-posterior **(1073)** and lateral views being taken and the exposures adjusted to its size.

It should be noted that for the lateral views an increase of 5 kilovolts is necessary.

The Potter-Bucky diaphragm may be employed if so desired, and shading may be applied to the limbs, or a graduated density wedge employed, to equalise the wide range of densities found in these subjects.

The following exposure factors are suggested:

A. 4 Months
B. Full Term

EXPOSURE FACTORS

kVp.	mA Secs Ilford X-ray	mA Secs Developers Blue Label	Distance	Film	Screens Ilford	Grid
A27	450	—	36"	Ilfex	—	
B32	600	—	36"	Ilfex		

Cone to size of film.

SECTION 27

Foreign Bodies

FOREIGN BODIES

Radiographic investigation to determine the presence and position in the body of any foreign object, termed a "foreign body," is an important part of the work of the X-ray department.

In time of war these examinations are met with in great numbers, the many types of injuries being almost always associated with the presence in the tissues of opaque, partially opaque or non-opaque objects of widely varying size, shape and material. There may be bone injury with extensive flesh wounds, or the surface wound may be only an almost invisible puncture; and the possibility of the presence of gas in the tissues has also to be borne in mind **(1076, 1076a).**

Foreign body problems occur at all times, however. The factories produce both minor and major accidents necessitating foreign body investigation, and in domestic life broken glass, needles, pins, coins and a great variety of objects which have found their way into superficial tissues or which have been inhaled or ingested are daily met with.

The method adopted to demonstrate the presence and, later, the precise location of a foreign body is governed by its size and degree of opacity and also by its approximate position. Unless it is radio-opaque, or is in a position where it can be coated with opaque material to render it visible as, for instance, in the alimentary tract—the foreign body cannot be shown by X-rays, although partially opaque bodies, such as wood and other low density materials producing soft shadows, may sometimes be shown by varying the kilovoltage for the purpose. Glass, it should be remembered, varies in opacity, and in the case of glass, therefore, a negative result is not necessarily an indication that no foreign body is present.

War injuries present the radiographer with many special foreign body problems, some of which are here discussed under three headings:—

1. *Initial routine casualty examination*, of immediate importance to indicate the extent of the injury. The presence of an opaque foreign body may also be disclosed.
2. *Anatomical location*, embracing extensive investigation to determine the precise position of the foreign body in relation to vital structures and to enable the surgical route for its removal to be determined. Such an examination by screening and radiography may involve unusual positioning, observation of respiratory movements, cross-sectional plotting of the foreign body on an anatomical chart, stereoscopy and so forth.
3. Precise *localisation of depth* immediately before the removal of the foreign body, which should be made only when, after viewing the preliminary films, the surgeon has indicated the route of removal. It will be appreciated that close co-operation with the surgeon is here most desirable, and it is advisable for the X-ray operator to accompany patients to the operating theatre at times in order to appreciate, as far as possible, the difficulties involved in applying a depth localisation.

Each stage has its particular application as treatment progresses, and it should be noted that localisation of depth is not usually the subject of the initial examination.

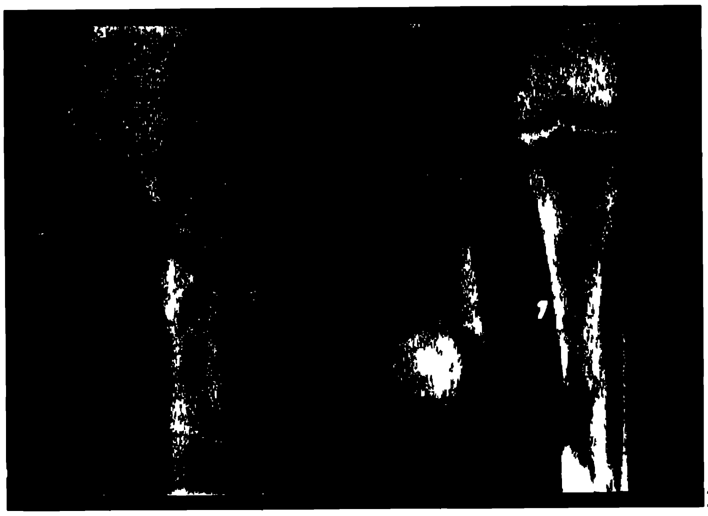
Initial Examination

As this volume gives details of routine examinations of every part of the body, reference should be made to the pages dealing with the region concerned. It is imperative that *true* antero-posterior and lateral views should be taken, that large area examination should be made of each region including the outline of the skin surfaces **(1076),** and that exposure technique should be adapted to demonstrate both bone and soft tissue to facilitate identification of the less opaque foreign bodies and particularly of the presence of gas in the tissues, as shown in **(1076),** in which case lead arrows have been placed on the skin to indicate the surface position of wounds. Reference should also be made to three cases **(1076a),** which illustrate two different types of gas gangrene.

An extensive surface wound will be apparent in the radiographs either as an irregular soft tissue outline in profile, or, as an area of greater density *en face*, as illustrated on page 470 **(1178c).**

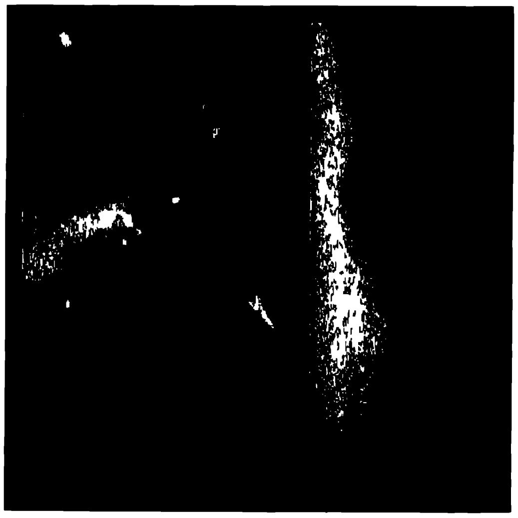
Investigation should otherwise be similar to that for general casualties, it being appreciated, however, that under war conditions this part of the work may of necessity be carried out under the most restricted conditions so far as apparatus and processing are concerned.

1076



1076a

1076b



1076d

Foreign Bodies

Anatomical Location

As stated earlier, this part of the examination may be extensive in character and may require the application of varying forms of radiographic technique. Only a limited number of examples can be given, as at this stage much depends upon the investigator's understanding of the films made at the initial examination.

For convenience, limbs, head and trunk are discussed separately, and illustrations are given for guidance and interest. The respiratory system and the alimentary tract are also discussed.

LIMBS

Two views should be taken—antero-posterior or postero-anterior, as may be necessary, and lateral *without moving the limb* from a pre-determined position, preferably the operative position for the removal of the foreign body. With the limb so placed the skin, on screening, may be marked from several aspects immediately in line with the foreign body **(1089a)**, page 426, to facilitate the reassumption of the posture later.

Oblique views may be taken to determine the relative positions of opaque object and bone, as shown in **(1076b)** which includes also true antero-posterior and lateral views. On examining this series of radiographs it will be seen that each foreign body is in turn shown to be separated from the bone shadow.

Correct projection may be obtained by screen examination, the film being exposed following visual separation of foreign body and bone shadows. Stereoscopic films may also be required.

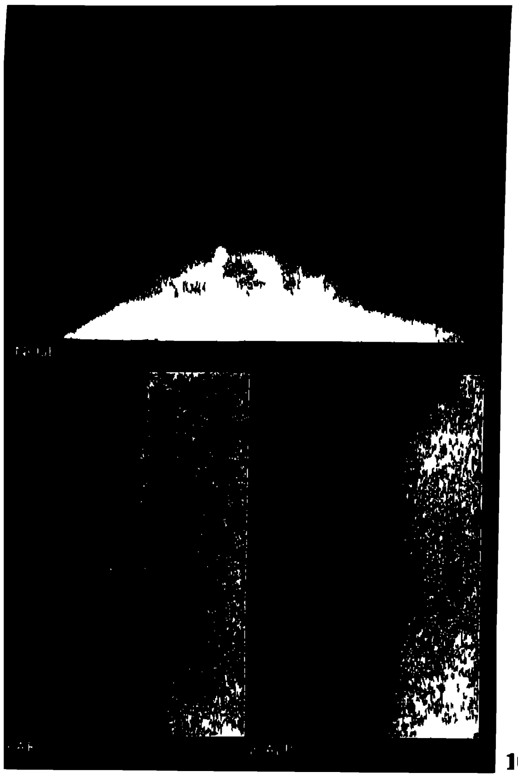
Special positioning of hand, thumb, forearm, foot and femur for foreign body investigation is given in foregoing sections, to which reference should be made.

HEAD

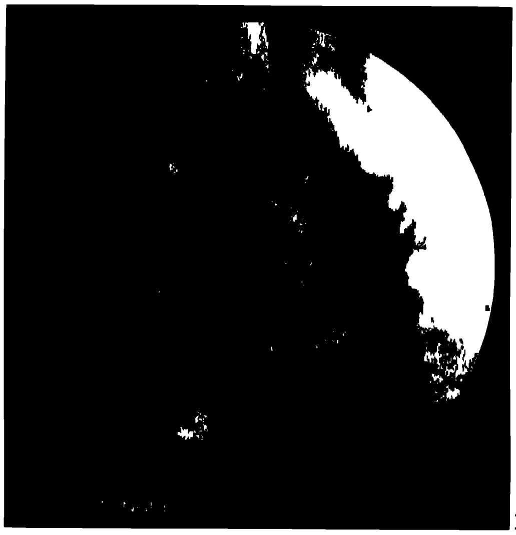
For descriptive purposes the head is divided into cranium and face, the latter being again sub-divided into general and localised regions such as the eye, nose, tongue and jaw.

In head work particularly it is sometimes necessary to demonstrate bone and soft tissues: when suitable a high kilovoltage may be applied to show both tissue densities on the one film; or one film may be placed between, and one film in front of, the intensifying screens for each exposure as shown in **(1076d)**. In this case a number of small foreign bodies are shown embedded in the soft structures. By taking soft tissue views from various

Foreign Bodies: Anatomical Location



1077



1077a

1077b

HEAD *(continued)*

aspects of the face the majority of the remaining foreign bodies were shown to be superficial, while the relative positions of the deeper fragments were readily disclosed.

When examining the *cranium* every effort should be made to identify the foreign body as being within the cranium, embedded in the bone wall, or in the scalp or adjacent soft tissues, and additional oblique, and "skyline" views **(1076d, 1077)** should be taken to show the foreign body in profile where applicable. Reference should here be made to page 184. In taking stereoscopic views it should be remembered that the head may be moved in place of the more usual movement of the tube; also that the *direction* of the tube shift depends on the region concerned, and movement may be parallel to the median line in place of the more usual transverse direction. If the apparatus is available, tomography or seriescopy may be invaluable. When the foreign body is proved to be within the bony cranium a precise localisation of depth will probably be required immediately.

In dealing with the *face* combined bone and soft tissue radiography is usually necessary **(1076d)** and special note should be made of the soft tissue radiographs of nose and ear in **(1077)**. Views such as occipito-frontal, occipito-mental, lateral and oblique, with such other views as may be required, will disclose the position of the foreign body and its relationship to bone and soft tissue structures. Radiography of the face is important also as an aid to plastic surgery.

To identify the presence of a foreign body in the *tongue* it will be necessary to make exposures with this organ at rest within the mouth **(1077a)** and, if possible, extended outside the mouth, when the relative position of the foreign body will be disclosed.

Lateral views should be taken of the *orbital cavity*, one with the eyes raised and the other with the eyes lowered in order to observe any movement of the foreign body. Reference should be made to **(1094b)**, page 438.

Two views, lateral and 30 degrees occipito-mental, selected from a series of radiographs taken after removal of the eye and replacement by a glass eye, are shown in **(1077c)**, the glass eye having been retained to serve as a landmark in identifying the relative position of foreign bodies adjacent to the orbital cavity.

In this instance the investigation was to identify the precise position of a foreign body in relation to the optic canal, initial exploratory exposures being followed by numerous localised views.

1077c

HEAD (*continued*)

In examining the *jaw* it may be extremely difficult to apply routine positioning and in the case of a gross injury it may be necessary to depend entirely upon the screen examination to enable the *relative* position of the foreign body to be recorded radiographically. Dental and occlusal films placed inside the mouth may serve to show the position of foreign bodies in *cheeks* or *lips*.

1078

TRUNK

The *shoulder* is not an easy region to demonstrate, and here again numerous "skyline" views may be necessary, especially to show foreign bodies in relation to the *scapula*, as in **(1078)**, where an oblique view has been taken to show that certain opacities appearing in the antero-posterior view are not in the lung. In **(1078c)**, also, an unusual oblique projection has been made to confirm the position of a bullet in the spine of the scapula. Careful screen examination is invaluable in this region to enable the foreign body to be shown in profile.

The position of the arm may be important when examining the *axilla*, as shown in **(1078a)**, taken with the arm both in adduction and abduction: lateral views with the arm abducted may also be informative **(96, 96a)**, page 40.

For the *clavicle* several additional projections may be made with the patient supine or lateral, and with the tube angled steeply toward the head, thus separating the opaque shadows from other structures, as shown in **(1078b)** which, incidentally, also gives a clear view of the apices of the lungs.

When, despite careful positioning, it is difficult to determine the relative position of the foreign body it should be remembered that a shadow-shift film will disclose, by parallax, page 431, the relative depths of the foreign body and adjacent structures, as illustrated in **(1091a, 1092, 1092b)**, pages 430, 434.

1078a

1078b

1078c

1078d

1079

TRUNK (*continued*)

In dealing with the *spine* **(1079)** additional oblique views **(1078d)** and stereoscopic views are usually necessary. Initial true antero-posterior and lateral views are essential, however, **(1079)**, following which very careful screen adjustment is required to disclose a foreign body in a position such as that shown in **(1078d)**.

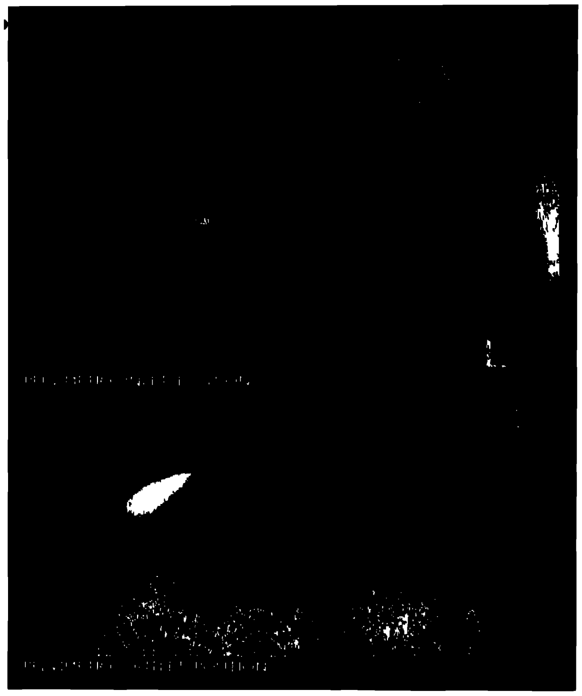
It is of interest to note that the antero-posterior view in **(1079)** is one of a pair of tomographs taken stereoscopically. In series **(1079a)**, showing a foreign body in the upper cervical region, the additional base view of the skull was taken to show the plan position of the foreign body in the atlas. These radiographs were selected from a number of views which left no doubt as to the precise position of the foreign body.

The *pelvis* lends itself to the taking of various additional oblique views **(1093)**, page 436: the pelvimetry inlet **(1079b)** and outlet **(1079c)** positions may also be informative, particularly the inlet, to show the position of foreign bodies in relation to the pubic bones **(1079b)**. In **(1079c)** a bullet is shown to be lodged in the sacrum, and in **(1093)**, page 436, a piece of shrapnel is seen 10 centimetres deep and so close to the iliac bone that the shadows could not be separated by oblique projection.

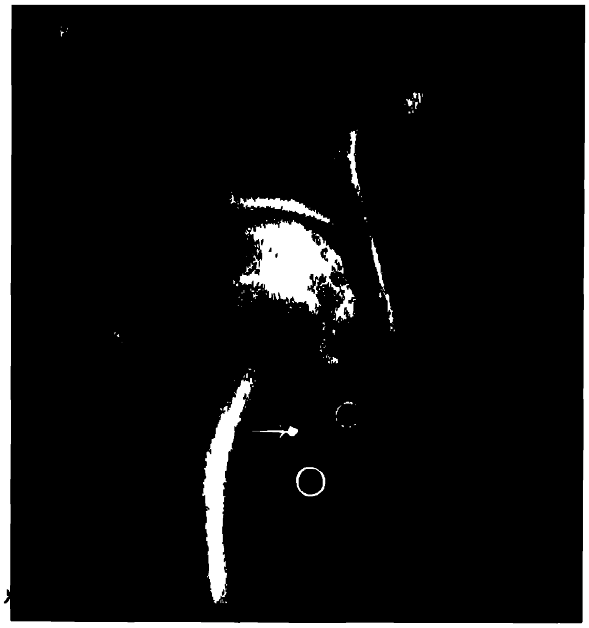
In examining the *hip joint* the general antero-posterior, lateral, lateral neck of femur, general lateral of pelvis **(1093)**, oblique and stereoscopic views are likely to be useful.

In **(1079d)**, one of a stereoscopic pair, metal rings have been placed on the skin surface to show the position of surface wounds, the near film ring shadow being the smaller.

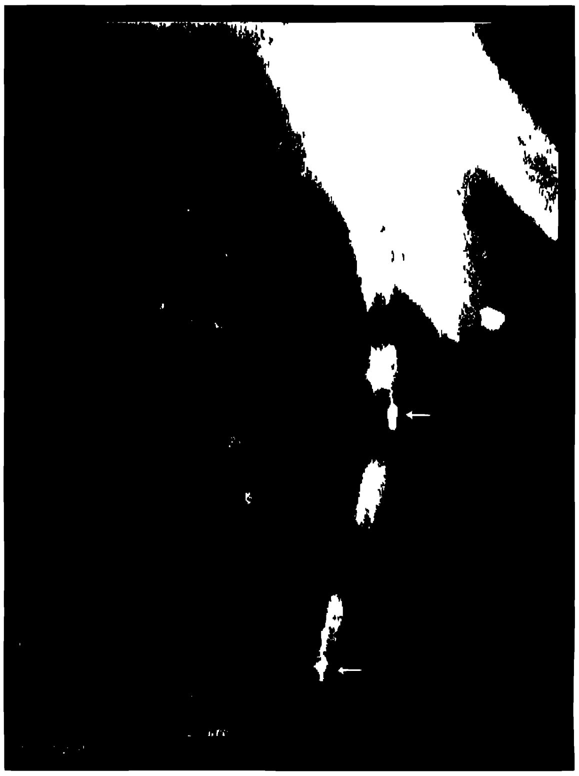
1079a



1079b
1079c



1079d



1079e

Foreign Bodies: Anatomical Location

TRUNK (*continued*)

The *buttock* is a particularly difficult region to examine, and here lateral and "skyline" views taken with the beam parallel to the iliac bone should be employed. It may also be helpful to place a small film well down in the crease between the buttocks and to direct the X-ray beam obliquely from the outer side. It is difficult in this region to determine the position of a broken hypodermic needle: reference should be made to (**1092**), page 434, which shows an ordinary sewing needle in the buttock, and to (**1093**), page 436, in which a piece of shrapnel is shown embedded deeply in the soft tissues.

It should be noted that in each of these shadow-shift illustrations the relative depths of foreign body and anatomical structures are disclosed.

In the *thorax* the adjacent scapulæ and clavicles have to be considered, as also the position of the foreign body relative to the organs and ribs. In (**1079e**) the foreign bodies marked by arrows are so near to the pleura that only the most critical screen examination disclosed their actual position and rendered radiographic record possible. Reference should be made also to (**1092c**), page 435, general lateral and localised oblique views, to radiographs (**1080**), showing a radium needle in the axilla, and (**1080a, 1081**), in which a small fragment of a needle is proved to be superficial.

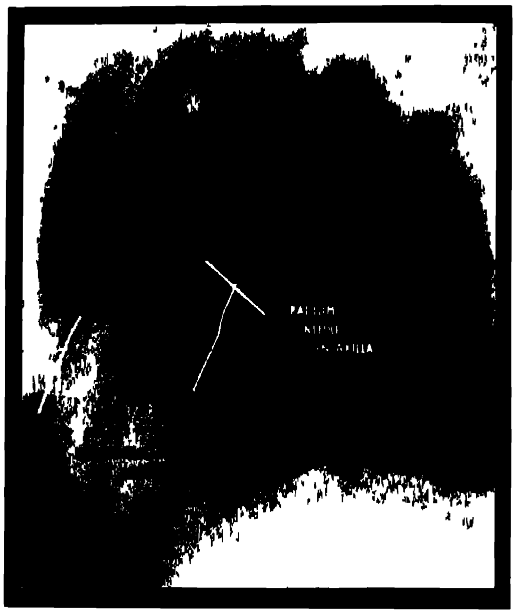
Screening for the relationship of foreign body movement and respiratory movement is important and is discussed on page 422.

The *diaphragm*, owing to its peculiar shape and movements during respiration, presents its own particular problems. Tangential views may be taken with the beam directed horizontally (**1082**), upward, and downward (**1083, 1084**), pages 422 3.

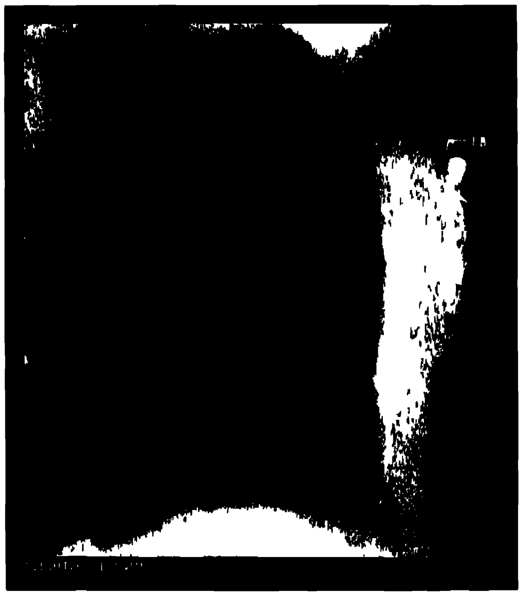
In the upper *abdomen* the position of the foreign body relative to the diaphragm is important and also the relative movements, on respiration, of the foreign body and of the visible organs affected also by respiration. Reference should be made to pages 423 to 425 discussing the *alimentary tract*.

Respiratory System

In dealing with the respiratory system the nature of the injury will, in the great majority of cases, indicate the approximate region to be investigated. In the case of gunshot and explosion wounds the condition of the patient may indicate that there is injury to the lung or mediastinal viscera, or suggest that the foreign body has


1080


1080a


1081

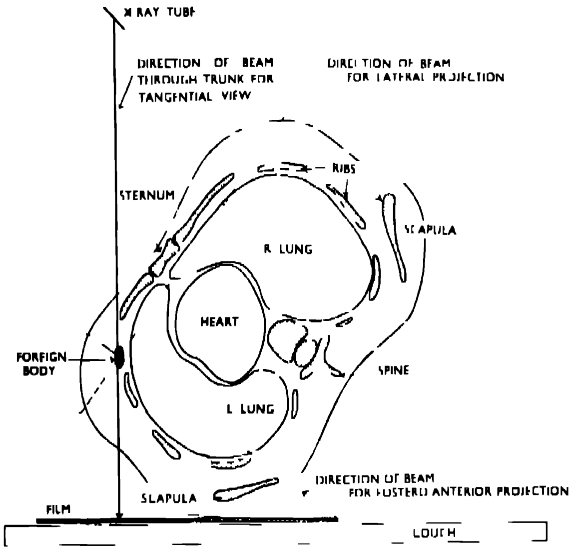
Foreign Bodies: Anatomical Location

RESPIRATORY SYSTEM *(continued)*
been arrested in the superficial tissues. On the other hand, solid matter inhaled into the breathing passages, the larynx, trachea and bronchi, present another problem: this mishap may occur during operation on the mouth, teeth or throat, but is most frequently sustained by children with the habit of putting things into their mouths, and serious lung injury may follow.

A bullet or piece of shrapnel piercing the chest wall and entering the pleural cavity may allow the entry of air also and thus cause a pneumothorax, with collapse of the lung, when the foreign body may be free to move about within the pleural cavity with change of posture of the patient.

A screen examination is essential in all these cases, as it discloses the movement of the foreign body during respiration: movement coincident with that of the ribs may confirm its presence in the thorax wall.

Tangential views will serve to locate the position of the foreign body, as shown in **(1080a, 1081)** and also **(1079e)**—in both cases outside the bony thorax. In **(1092c)**, however, the foreign body is shown to be inside the bony thorax. The principle of tangential projection is shown in cross-sectional diagram **(1082)**.

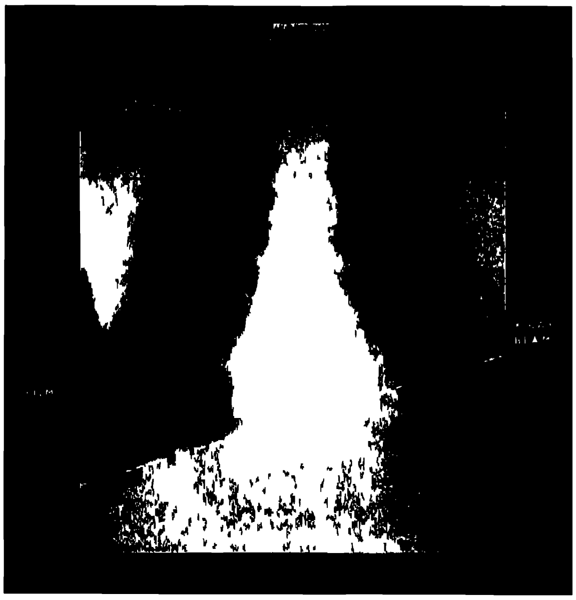


1082

Initial films should, however, be taken from two right-angled aspects, postero-anterior or antero-posterior and right or left lateral, according to the near-skin surface of the foreign body.

The more opaque bodies will be easily seen and a precise localisation of depth may be necessary, a careful note being made of the phase of respiration. It is recommended that exposure be made on expiration.

The less opaque foreign bodies—a single tooth is an example—partially obscured as they may be by the dense



1083

1084

1084a

Foreign Bodies: Anatomical Location

RESPIRATORY SYSTEM (*continued*)

hilar lung shadows, are not easily seen unless the finest possible lung definition is obtained on the film. The examination should, therefore, be most exacting, as the continued presence of a foreign body in the lung, with the probability of its setting up a septic condition, may endanger the life of the patient.

When the patient's symptoms indicate the continued presence in the lungs of a foreign body which has not been identified radiographically, the physician may resort to bronchography, discussed on page 320, to determine the site of the obstruction (**1084a**).

Tomography, discussed in Section 21, may also be used to locate the foreign body (**1084b**). It should be appreciated, however, that tomography does not necessarily permit of *precise* localisation of depth. As an alternative to tomography seriescopy may be employed as discussed on page 488.

In the case of an opacity overshadowed by the diaphragm additional views, tangential to the diaphragm, are taken from both aspects to determine its position as being above or below the diaphragm (**1083, 1084**). Reference should here be made to previous remarks under *thorax*, page 421.

Alimentary Tract

It is frequently necessary to examine the alimentary tract for the presence of foreign matter of many kinds which has been swallowed—sometimes intentionally.

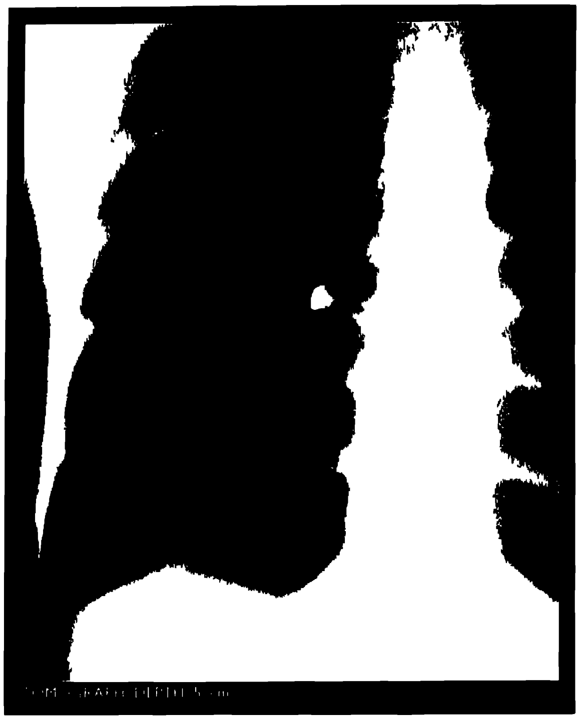
For the purpose of this section the alimentary tract is treated in three parts, the pharynx and upper œsophagus, the œsophagus, and the gastro-intestinal tract.

PHARYNX AND UPPER ŒSOPHAGUS

The swallowing of small bones is a common occurrence, and these, especially fish bones, may be almost non-opaque and thus require special technique.

These shadows can be localised by taking a lateral view of the neck to show soft structures only, for which purpose the neck should be extended, the shoulders depressed, and the tube centred high up at the level of the third cervical vertebra in order to show the maximum area of œsophagus above the dense shoulder structures, this positioning being similar to that applied for the lateral cervical spine, pages 120 and 121.

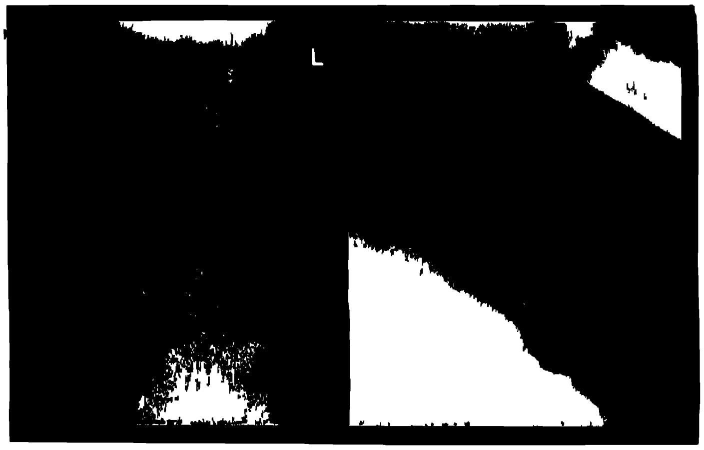
A thick barium swallow may be given to show or to confirm the presence of a foreign body, which usually



1084b

1085

1086



1087

Foreign Bodies: Anatomical Location

PHARYNX AND UPPER ŒSOPHAGUS *(continued)*
takes a thin, outlining coating. The swallow may be a mixture of barium and cotton wool, termed a bolus, of which the wool may be caught by the foreign body and so indicate its presence, but as in practice this rarely occurs, the procedure usually adopted is to take the lateral, soft tissue view, followed by a second film taken after the passage of the barium swallow has been viewed on the fluorescent screen. Illustration **(1085)** shows a fish bone in the pharynx, before and after a barium swallow. In **(1086)** a piece of gristle and a coin are seen in the upper œsophagus. Number **(1087)** shows a needle in the throat, in this instance the postero-anterior view replacing the barium swallow.

A patient's complaint of persistent pain in the throat should not be accepted as conclusive evidence of the presence there of a foreign body, as the discomfort may be due to an abrasion caused by its passage to a position lower down in the alimentary tract.

ŒSOPHAGUS

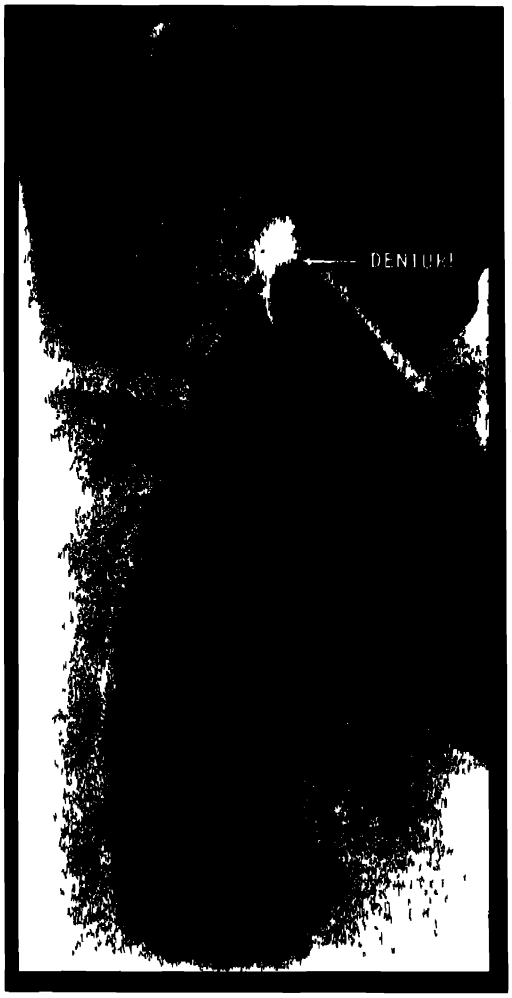
Apart from X-ray evidence, the patient's symptoms will have indicated to the physician whether the foreign body is in the bronchus or the œsophagus.

The œsophagus is viewed with the patient in the right anterior-oblique position, as described on page 335. Unless an opaque foreign body is shown to be present, as in **(1088)**, or if a non-opaque foreign body is anticipated, a thick barium swallow is given to locate the obstruction.

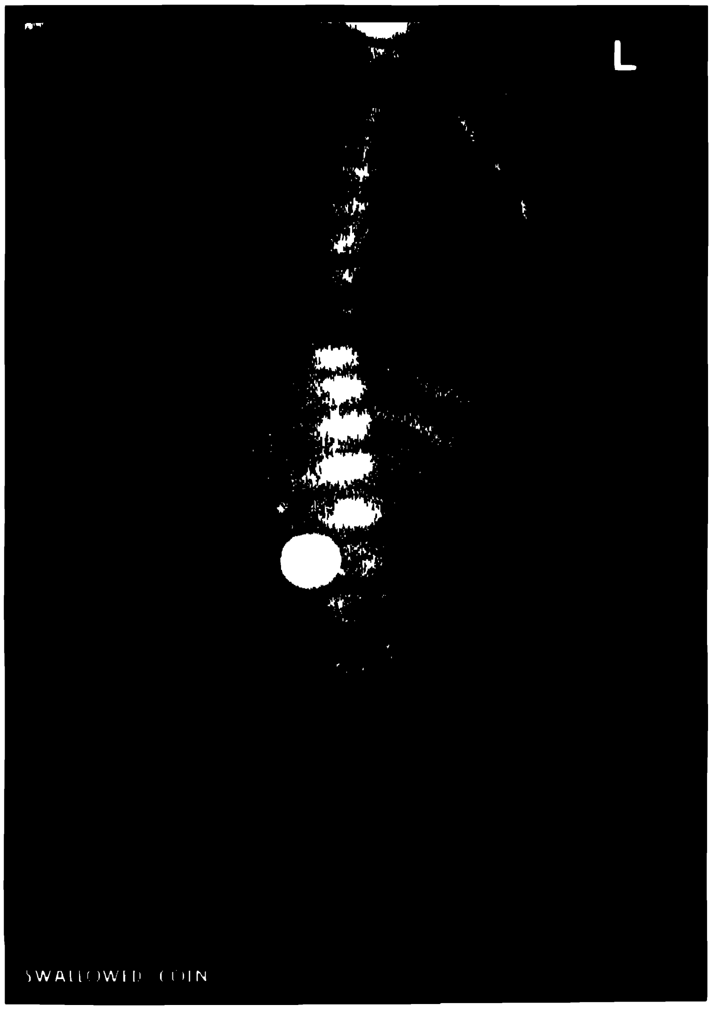
When, however, there is doubt as to the radio-opacity of the foreign body and it is not shown in the screen examination of the œsophagus, a general view of the *abdomen* should be taken on the Potter-Bucky couch before administering the barium swallow, as the opaque meal, when it reaches the gastro-intestinal tract, would probably obscure the foreign body should it have passed beyond the œsophagus.

GASTRO-INTESTINAL

For the remainder of the tract a general view of the abdomen is taken, usually daily, to observe the progress of the foreign body, the chief anxiety being in its possible failure to pass the narrow ileo-cæcal valve at the junction of the small and large intestine. Should operative measures be contemplated the patient should be radiographed again immediately before the operation to ensure that the foreign body has not, in the meantime, been evacuated unnoticed.



1088



1089

Foreign Bodies: Anatomical Location

GASTRO-INTESTINAL (*continued*)

The presence of a *non-opaque* foreign body suspected of causing an obstruction may be confirmed and its position determined by the ingestion of a small barium meal, the flow of which will be wholly or partially arrested by the obstruction. A small meal may also be given to determine the precise position of the *opaque* foreign body.

In dealing with one or several small opaque bodies it is essential to take the general view of the abdomen on the Potter-Bucky couch, using a short exposure technique. On taking the film in the screening stand without a grid these opacities may be missed, as the secondary radiation is considerable when covering this large area with an open diaphragm and may be sufficient to diffuse the small shadows, it being probable that no trace of them will be seen either in the film or by screen examination. The film taken with the grid, however, will show them clearly.

In dealing with young children it is advisable to avoid screening, if possible, and to confine the examination to a general view of the abdomen and thorax (1089). Should further investigation be necessary, an oblique view of the thorax, to show the œsophagus, and a lateral view of the chest and throat cavity will generally suffice to complete the examination.

In older children a brief screen examination will serve to locate an opaque foreign body, and confirmatory films may then be exposed to cover the region involved. In making the screen examination the whole of the alimentary tract should be covered from the mouth to the anus, as otherwise a foreign body close to either of these, but especially in the throat, may be overlooked.

The progress of the swallowed open safety-pin should be carefully observed from day to day.

In cases of an ingested foreign body it is usual for instructions to be given for the patient to take thick, stodgy food, and for the fæces to be examined for the presence of the foreign body after each evacuation.

For these investigations of the trunk the patient's clothing should be replaced by a hospital gown which is known to be free from opaque fastenings.

Localisation of Depth

Before discussing actual localisation methods there are certain preliminaries to be considered, including the patient, removal under screen, the foreign body, apparatus both general and special, processing, preliminary practice work on models, and geometric principles involved

Foreign Bodies: Localisation of Depth

The Patient

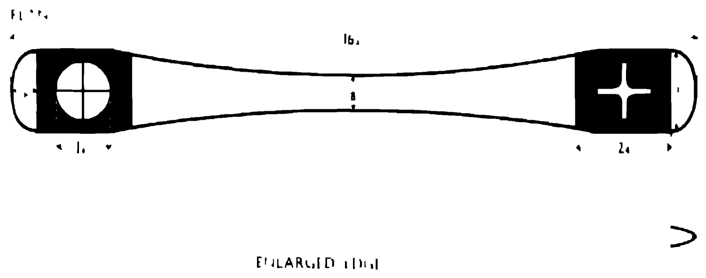
Whether the depth localisation is carried out with the overhead or undercouch tube the surgical skin surface should always be uppermost, and there should be no compression of these tissues **(1091c)**. It is essential, therefore, when the screen is not attached to the tube column, to support the screen or cassette at skin level, using a specially constructed adjustable wooden stand or a pair of Finzi plate holders.

When the cassette or screen is not in contact with the skin surface the intervening space should be measured and, together with the thickness of the apparatus, deducted from the ascertained distance between the foreign body and the film or screen surface. In the case of the cassette the distance between the front and the film is approximately one sixteenth of an inch, and in screening the distance between the active surface and back of the screen frame is approximately half an inch **(1089a)**. These thickness measurements should, indeed, be clearly shown on all cassettes and fluorescent screen frames employed for localisation **(1091c)**, page 432.

In dealing with curved surfaces such as the buttock, or over a wounded area, the depth measurement should be made from the highest adjacent skin level **(1092d)**, page 435. The position of a wound and its extent may be indicated by metal markers placed on the film or skin, as in **(1076, 1079d)**, pages 417 and 421.

MARKING THE SKIN SURFACE

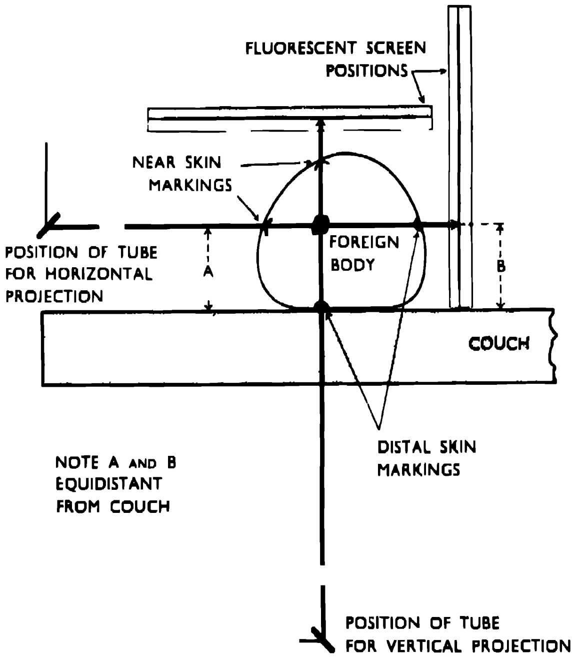
The patient is screened, the diaphragm aperture being reduced to include only a small area, with the tube centred directly through the foreign body.



The skin position may be found by placing an instrument shaped like a spatula (as above) under the screen, with either the cross-wires or the open cross in position over the foreign body, the skin being marked on the removal of the screen either directly through the cross or at the centre of the impression made by the cross-wires on the skin.

When only the surgical skin surface position of the foreign body is required for immediate operation, the accepted method of marking this point is to make a small cross on the skin with a surgical needle which is kept sterile for the purpose in a rubber-capped bottle. For convenience this bottle may be strapped to the couch in order to be in immediate readiness, together with a small bottle of iodine for application to the skin area concerned.

When the patient is to be moved, after examination, from the X-ray room to the theatre it is the practice to mark the skin from three aspects—antero-posterior, medial and lateral—to facilitate the reassumption of the screening position for the operation. A horizontal tube projection is employed for the medial and lateral markings, and these, being equidistant from the couch, provide the necessary guidance for correct positioning and also indicate the depth of the foreign body **(1089a)**. A cross in place of a spot may be used to show the near skin surface from both aspects **(1089a)**. Care should be taken to ensure that the tube is correctly centred for each of these projections. Reference should here be made to "Tube Centring," page 427.



1089a

Guidance marks for positioning only may, of course, be made by direct measurement, horizontal tube projection being thus avoided.

On being given a skin marking over the foreign body and the depth of the foreign body below this point, the surgeon is able to determine the correct angle at which to approach the foreign body from any adjacent skin surface position.

MARKING THE SKIN SURFACE (*continued*)

There is sometimes a request for a piece of metal wire to be strapped to the skin surface and left in position after the films have been exposed in order that the relationship between the metal and the foreign body may be the better appreciated on both subject and film **(1080)**, page 422.

Removal under Screen

The surgical removal of foreign bodies under the fluorescent screen should *not* be encouraged. Such removals are at times unavoidable, however, especially for such regions as the hands and feet, in which case the following precautions should be observed:—

(1) ANÆSTHETIC

The anæsthetic may be either general or local, the use of ether being avoided in view of its great inflammability, especially when an older type of apparatus is in use.

(2) HIGH TENSION

When the apparatus is not of the shock-free type every precaution should be taken to ensure that patient, surgeon, anæsthetist and assistants cannot come into contact with the high-tension system.

(3) SCREENING PERIOD

In the absence of the radiologist the radiographer is usually in charge of the screening facilities during minor surgical operations in the X-ray department, and every precaution should be taken to ensure that the screen examination is not prolonged unduly, risk of over-exposure to surgeon, patient and others being thus avoided. The first essential is insistence on visual sensitivity, which may be obtained by allowing a lapse of at least ten minutes in the darkened room before screening.

Under routine screening conditions, that is, at 80 kilovolts, 3 milliamperes, 20 inches anode to *near skin* distance, and using a 1 millimetre aluminium filter, an exposure of $12\frac{1}{2}$ minutes, or 2250 milliampere-seconds, may be applied to a single skin area, and the dose should not be repeated until after a *minimum interval of three weeks*.

This allows ample time for the most exhaustive screen examination as screening is always carried out in intermittent periods of short duration, although an actual surgical operation may take an hour, or even more. It is informative to check off the *actual screening time* during the removal of a foreign body, using a stop watch or a darkroom clock.

Foreign Bodies

Any type of material may be included under this heading and, as seen in the various illustrations, there may be present *one* foreign body *or many*. In the latter case the surgeon will indicate those to be removed, and these should be carefully noted for identification, **(1) (2) (3)**, etc.

In the case of large foreign bodies it may be necessary to give numerous depth measurements in order that the general position in the tissues may be known.

Foreign bodies with smooth surfaces, such as a needle or a bullet, may move as the subject moves, passing from one tissue layer to another, hence the importance of immobilising the patient during the interim between localisation and removal. This type of foreign body tends to rotate and alter position when touched by the surgeon's probe, which may thus pass the foreign body. On the other hand, an irregularly shaped mass will probably be fixed in the tissues, moving only with the muscles and not from layer to layer.

In dealing with material of which the radiographic density is likely to be doubtful it is sometimes possible to obtain a piece of similar material for screen examination: this applies particularly when such objects as buttons have been swallowed, or when glass enters the tissues.

Apparatus

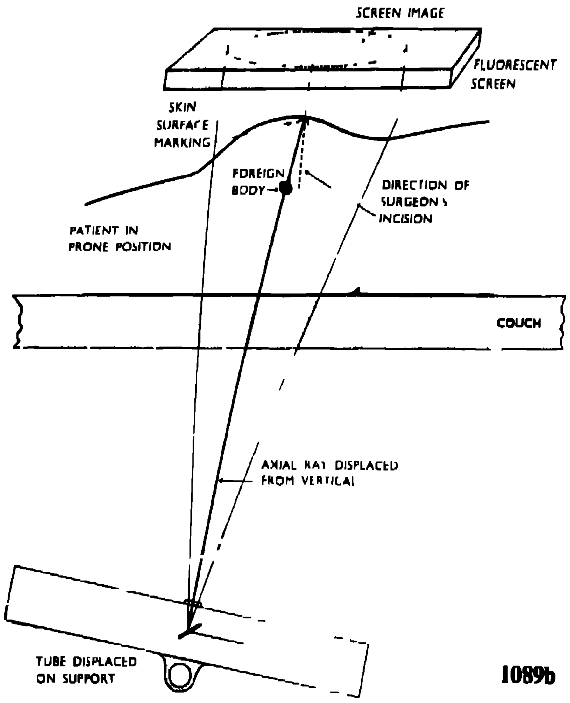
Each available unit should be considered from the point of view of its adaptability and its possible limitations for depth localisation: much preliminary work can be done in providing for accurate tube centring, for a simple method of measuring the anode-film distance and tube shift, and also in providing suitable accessories.

TUBE CENTRING

Accuracy in localisation is dependent initially on the tube being placed with the aperture horizontal so that the *axial* ray is *vertical* and *central* to the beam aperture. When the tube is tilted longitudinally as shown in **(1089b)**, or rotated about its diameter, the centre of the screen image does not coincide with the *vertical* ray from the tube but to the *axial* ray, which is directed obliquely.

It follows that a skin marking made in such circumstances for the "guidance" of the surgeon is misleading, any marking being presumed to be, as it should be, vertically over the foreign body **(1089b)**, page 428.

TUBE CENTRING *(continued)*



1089b

Of the many simple devices for checking the tube position the one here described has the advantage of being applicable to both overhead and undercouch tube positions.

X-RAY BEAM CENTRING DEVICE

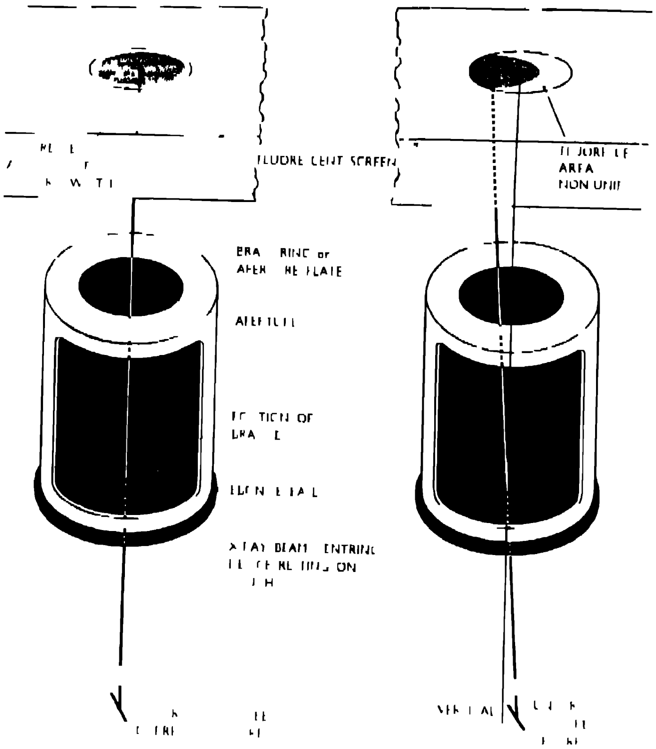
The centring device should be used only as a periodical check on the tube position and then only when the construction of the tube support is such that the tube can be unintentionally decentred during use. In certain cases, however, where the tube focus is the axis of movement, the relative fixed position of the rectangular diaphragm may be such that in each decentred position of the tube the vertical ray is central to the fluorescent area on the screen.

Briefly, the centring device consists of a hollow brass cylinder, 3 inches in length and $2\frac{1}{4}$ inches in diameter, having a full-length cut-away viewing window in one side. The interior is blackened. One end of the cylinder, *partly* closed, is of brass, there being a central circular opening $1\frac{1}{2}$ inches in diameter. The other, or disc end, *wholly* closed, is of ebonite, a material transparent to X-rays, and has a centrally situated brass disc $1\frac{1}{8}$ inches in diameter. The difference between the diameter of the aperture at one end and the diameter of the disc at the other is therefore three-eighths of an inch **(1090)**.

For *undercouch* tube adjustment the centring device is placed with the disc end in contact with the couch facing the X-ray tube and the open end in contact with the fluorescent screen **(1090)**.

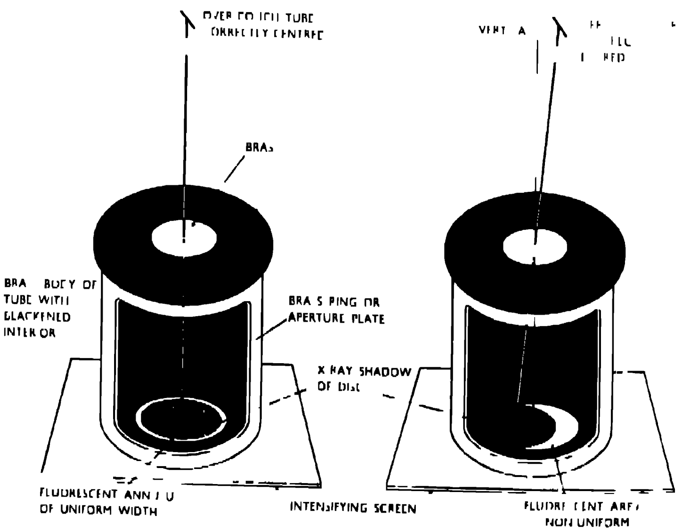
On the tube being activated the diaphragm is reduced to a small aperture and the centring device moved to the centre of the X-ray beam, a shadow of the disc being thus produced within the aperture.

When the tube is correctly centred the disc shadow is surrounded by a narrow regular ring or annulus, irregular fluorescence indicating incorrect centring **(1090)**.



1090

When the centring device is used for *overcouch* tube centring a small localising cone is employed and the fluorescent screen is used *without lead glass:* a piece of old intensifying screen will serve for this purpose **(1090a)**.



1090a

X-RAY BEAM CENTRING DEVICE *(continued)*

The open end of the cylinder is placed in contact with the screen and the projection of the disc within the ring is viewed through the cut-away side of the cylinder **(1090a)**.

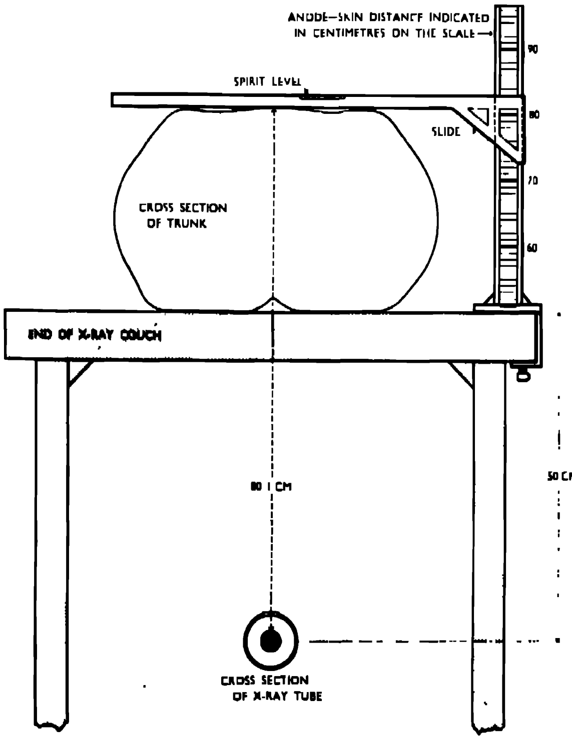
For both undercouch and overcouch work it is essential to place the centring device on a *horizontal* surface in the centre of the area of fluorescence before noting the position, central or otherwise, of the disc shadow.

ANODE-FILM DISTANCE

When undercouch work can only be carried out with tube and couch in fixed positions the distance from anode to couch top should be recorded on the couch for ready reference, this distance being added to the couch to film distance to obtain the anode to film distance. A simple accessory for measuring the couch top to film distance is shown in **(1090b)**, and consists of an adjustable horizontal arm moving over a vertical scale which, it should be noted, is graduated to give a direct anode to film reading.

ANODE TO TABLE-TOP DISTANCE

To determine the anode to table-top distance a flat metal object, such as a penny, is placed on the top of the couch, and after screening for position a film is supported horizontally at a known distance above the metal object and an exposure made; the tube is moved a known distance for convenience 10 centimetres, and a second exposure made **(1090c)**.



1090b

The displacement between the two shadows of the metal object is measured and the following formula applied:—

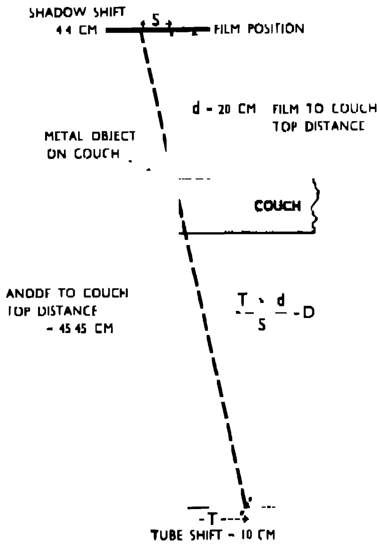
$$\frac{T \times d}{s} = D;$$

when

T = tube shift;
d = table top to film distance;
s = shadow shift registered on the film; and
D = anode to table-top distance.

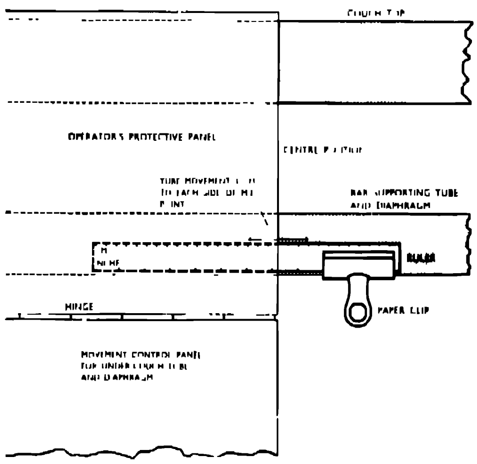
In the instance shown in **(1090c)** the distance is found to be:—

$$\frac{10 \times 20}{4 \cdot 4} = 45 \cdot 45 \text{ centimetres.}$$



1090c

Exposure technique:— 50 kilovolts, 20 milliamperes, and one-and-a-half seconds exposure for each tube position: Ilfex film.

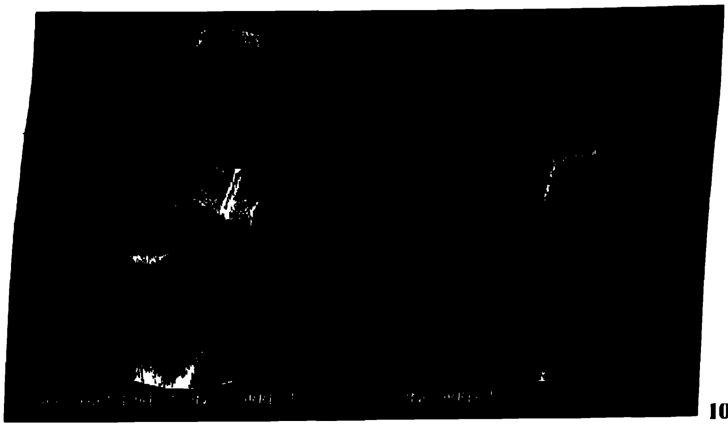


1091

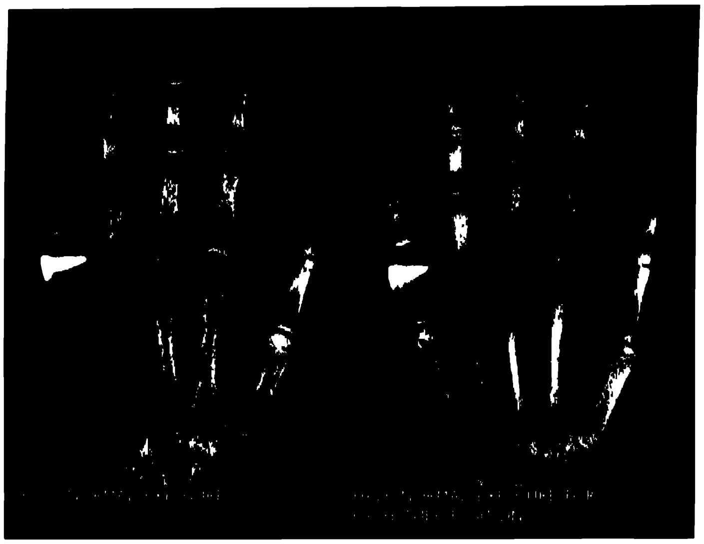
TUBE SHIFT

Tube shifts of 10 centimetres or 6 centimetres are usually employed. The greater tube shift should be applied in taking a near-film foreign body and also when the anode-film distance is considerable. When these conditions are reversed, however, the lesser tube shift should be employed: it is, indeed, the more commonly used.

Foreign Bodies: Localisation of Depth



1091a



1091b

TUBE SHIFT *(continued)*

When conditions are suitable a metal ruler may be clipped on to the couch side bar in such a position as to enable the tube movement to be adjusted to the ruler reading. By employing a celluloid set-square a *precise* ruler reading may be obtained **(1091)**, page 429.

It should be understood that the tube movement may be made so that the two exposures are equidistant from the foreign body centring point, as is necessary when employing the localiser illustrated in **(1092c, 1092d)** and in spectacle eye localisation shown on pages 444 to 446, or the total tube shift may be made to one side of the centring point as shown in **(1092a, 1093a)**. All existing automatic stereoscopic tube shift movements should be checked before being accepted as precise measurements for depth localisation.

The tube shift should be made at right angles to the long axis of an elongated foreign body **(1091a, 1092)**, and all film shadow-shift measurements should be made between the same two points on the foreign body shadows **(1093b)**. It will be understood that only half of the normal exposure is applied for each tube position **(1091b)**.

LOCALISATION TABLE FOR A TUBE SHIFT OF 60 mm., AN ANODE HEIGHT OF 500–800 mm., AND SHADOW SHIFT OF 0·5- 20 mm.

Anode mm.	0·5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
500	4·1	8·2	16·1	23·8	31·2	38·5	45·4	52·2	58·8	65·2	71·4	77·4	83·3	89	94·6	100	105·3	110·4	115·4	120·2	125
510	4·2	8·4	16·5	24·3	32	39·2	46·4	53·3	60	66·5	72·8	79	85	90·8	96·7	102	107·4	112·6	117·7	122·7	127·5
520	4·3	8·5	16·6	24·8	32·5	40	47·3	54·3	61·2	67·8	74·3	80·6	86·6	92·8	98·4	104	109·5	114·8	120	125·1	130
530	4·4	8·7	17	25·2	33·1	40·8	48·2	55·4	62·3	69·1	75·7	82·1	88·3	94·4	100	106	111·6	117	122·3	127·5	132·5
540	4·5	8·9	17·4	25·7	33·8	41·5	49	56·5	63·5	70·4	77·1	83·7	90	96·2	102·2	108	113·7	119·2	124·6	129·9	135
550	4·5	9	17·7	26·1	34·4	42·3	50	57·5	64·7	71·7	78·5	85·2	91·7	98	104	110	115·8	121·4	126·9	132·3	137·5
560	4·6	9·2	18	26·7	35	43·1	50·9	58·5	66	73	80	86·8	93·3	99·8	105·8	112	117·9	123·6	129·2	134·7	140
570	4·7	9·3	18·4	27·1	35·6	43·8	51·8	59·6	67	74·4	81·4	88·3	95	101·5	107·8	114	120	125·8	131·5	137·1	142·5
580	4·8	9·5	18·7	27·6	36·2	44·6	52·7	60·6	68·2	75·7	82·8	89·9	96·6	103·3	109·7	116	122·1	128	133·8	139·5	145
590	4·9	9·7	19	28·1	36·9	45·4	53·6	61·6	69·4	77	84·3	91·4	98·3	105·1	111·6	118	124·2	130·2	136·1	141·9	147·5
600	5	9·8	19·3	28·6	37·5	46·3	54·5	62·7	70·6	78·3	85·7	93	100	106·9	113·5	20	126·3	132·4	138·4	144·3	150
610	5	10	19·7	29·1	38·1	46·9	55·5	63·7	71·7	79·6	87·1	94·5	101·8	108·6	115·4	22	128·4	134·6	140·8	146·7	152·5
620	5·1	10·2	20	29·5	38·7	47·7	56·3	64·8	72·9	80·9	88·5	96·1	103·3	110·4	117·3	24	130·5	136·8	143·2	149·1	155
630	5·2	10·3	20·3	30	39·4	48·5	57	65·8	74·1	82·2	90	97·6	105	112·2	119·2	26	132·6	139	145·4	151·5	157·5
640	5·3	10·5	20·6	30·5	40	49·2	58·2	66·9	75·3	83·5	91·4	98·2	106·6	114	121·1	28	134·7	141·3	147·7	153·9	160
650	5·4	10·7	20·9	31	40·6	50	59	67·9	76·5	84·8	92·8	100·7	108·3	115·7	122·8	130	136·8	143·5	150	156·3	162·5
660	5·5	10·8	21·3	31·4	41·2	50·8	60	69	77·6	86·1	94·3	102·3	110	17·5	124·8	132	138·9	145·7	152·3	158·7	165
670	5·5	11	21·6	31·9	41·9	51·6	61	70	78·8	87·4	95·7	103·8	111·7	19·3	126·7	134	141	147·9	154·6	161·1	167·5
680	5·6	11·1	21·9	32·4	42·5	52·4	61·8	71	80	88·7	97·1	105·4	113·3	21·1	128·7	136	143·1	150·1	157	163·5	170
690	5·7	11·3	22·2	32·9	43·1	53·2	62·7	72·1	81·2	90	98·5	106·9	115	22·9	130·5	138	145·3	152·3	159·2	165·9	172·5
700	5·8	11·5	22·6	33·3	43·7	53·9	63·6	73·1	82·3	91·3	100	108·5	116·6	24·7	132·4	140	147·4	154·5	161·5	168·3	175
710	5·9	11·6	22·9	33·8	44·4	54·7	64·5	74·2	83·5	92·6	101·4	110	118·3	26·4	134·3	142	149·5	156·7	163·8	170·8	177·5
720	6	11·8	23·2	34·3	45	55·4	65·5	75·2	84·7	93·9	102·8	111·6	20	28·2	136·2	144	151·6	158·9	166·2	173·2	180
730	6	11·9	23·5	34·8	45·6	56·2	66·4	76·3	86	95·2	104·3	113·1	21·7	130	138·1	146	153·7	161·2	168·5	175·6	182·5
740	6·1	1	23·9	35·2	46·2	57	67·2	77·3	87	96·5	105·7	114·7	23·3	131·8	140	148	155·8	163·4	170·8	178	185
750	6·2	·3	24·2	35·7	46·8	57·7	68·2	78·2	88·2	97·8	107·1	16·2	25	133·6	141·9	150	157·9	165·6	173·1	180·4	187·5
760	6·3	·5	24·5	36·2	47·5	58·5	69·1	79·4	89·4	99·1	108·5	17·8	26·6	135·3	143·8	152	160	167·8	175·4	182·8	190
770	6·4	·6	24·8	36·7	48·1	59·2	70	80·4	90·6	100·4	110	119·3	28·3	137·1	145·8	154	162·1	170	177·7	185·2	192·5
780	6·4	2·8	25	37·1	48·7	60	70·9	81·5	91·8	101·7	111·4	20·9	130	138·9	147·5	156	164·2	172·2	180	187·6	195
790	6·5	13	25·5	37·6	49·4	60·8	71·8	82·5	92·9	103	112·9	22·4	131·7	140·7	149·4	158	166·3	174·4	182·3	190	197·5
800	6·6	13·1	25·8	38·1	50	61·7	72·7	83·6	94·1	104·3	114·3	24	133·3	142·5	151·3	160	168·4	176·6	184·6	192·4	200

Processing

When working with the surgeon in the operating theatre it is imperative to work quickly, and rapid processing methods should therefore be adopted.

The use of rapid radiographic developer enables development to be completed in 15 seconds, and the total processing time, embracing rinsing, fixing, and final rinsing, should be completed in one minute. In applying such short processing time the whole of the film must be immersed at once, a little practice being required when dish development is employed to produce an evenly developed film (1091a).

Preliminary Experiments

It is advisable to make initial depth localisations on a model, the following being suggested for instructional purposes.

(a) Two wooden blocks, 6 inches high, are placed together with a metal object strapped at varying positions to one of the opposing surfaces: exposures may be made for the purpose of checking the film or screen to foreign body depth calculations.

Exposure Technique:—50 kilovolts; 20 milliamperes; 60 centimetres anode-film distance; Ilfex film; total exposure three seconds, *i.e.*, one and a half seconds for each of the two tube positions. As a more realistic subject a loaf of bread, a marrow or a turnip may be used, when, on introducing a probe or steel knitting needle from two right-angle aspects, two further exposures will disclose the degree of accuracy of the localisation.

(b) *Eye*. To represent the eyeball, a 24 millimetre sphere may be cut from a potato, or moulded in paraffin wax, and wedged with cotton wool into an orbital cavity of a dried skull, the "pupil" being outlined on the model eye. Shot or small fragments of metal placed within and behind the model eye provide a satisfactory subject on which to practise the intricacies of eye localisation.

Exposure Technique:—50 kilovolts; 40 milliamperes; 50 centimetres anode-film distance; No. 5 (fast) Dental Film; total exposure one and a half seconds, *i.e.*, three-quarters of a second for each of two tube positions. Reference should be made to pages 442 to 446.

Geometrical Projection

Routine radiography is in flat projection, that is, in two dimensions. Localisation, however, requires radiographic investigation in *three* dimensions, as in stereography. Most localisation methods utilise the data derived from two or more shadows of the foreign body produced on the screen, film, or films by the displacement of the tube between two exposures. This is the basis of "similar triangles" localisation, or so called triangulation method, on which the majority of localisation methods depend and which was evolved by the late Sir James Mackenzie Davidson.

Other methods depend on *parallax*, *i.e.*, the apparent displacement of an object caused by an actual change of the point of observation.

This phenomenon is demonstrated under the fluorescent screen when a probe is placed at the supposed level of a foreign body, the position being confirmed or otherwise on the tube movement disclosing either the similar or dissimilar degree of movement of foreign body and probe, the probe being manipulated until it and the foreign body move in unison.

Margin of error. Radiographic localisation, although *theoretically* accurate cannot be *practically* so, absolute precision not being possible as the body cannot be treated as a motionless symmetrical solid. In general work an error of not more than 5 millimetres is permissible, but in special work, such as the examination of the eye, the variation should not exceed one millimetre.

Methods

There are many methods of localisation, but only one or two of the most popular are here described for each of four purposes.

Each method provides for (a) marking or identifying the surface position immediately over the foreign body, and (b) estimating the depth of the foreign body immediately below the skin surface or from a given skin level. They are described under the following headings:—

(1) Screen only—Screen Localiser.
(2) Screen and film—(a) similar triangles; (b) parallax.
(3) Film only—adaptation of similar triangles method for over-couch tube work when screening facilities are not available.
(4) Orbital cavity.

Screen only: Screen Localiser

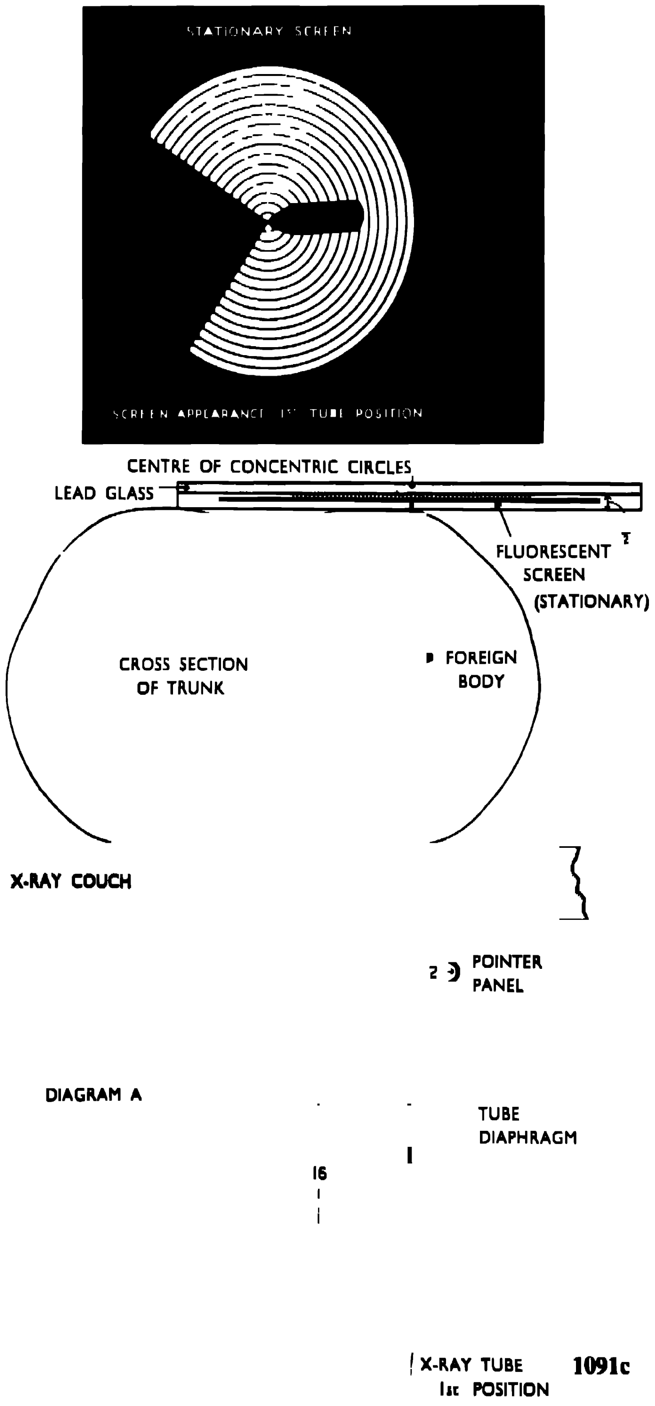
This method is not intended for precise localisation, but it has the advantage of being easy of application and of giving adequate information in cases requiring immediate treatment. It is possible to judge to within a quarter of an inch the depth of a foreign body in the thinner regions, and to within half an inch in the thicker regions.

SCREEN ONLY: SCREEN LOCALISER *(continued)*

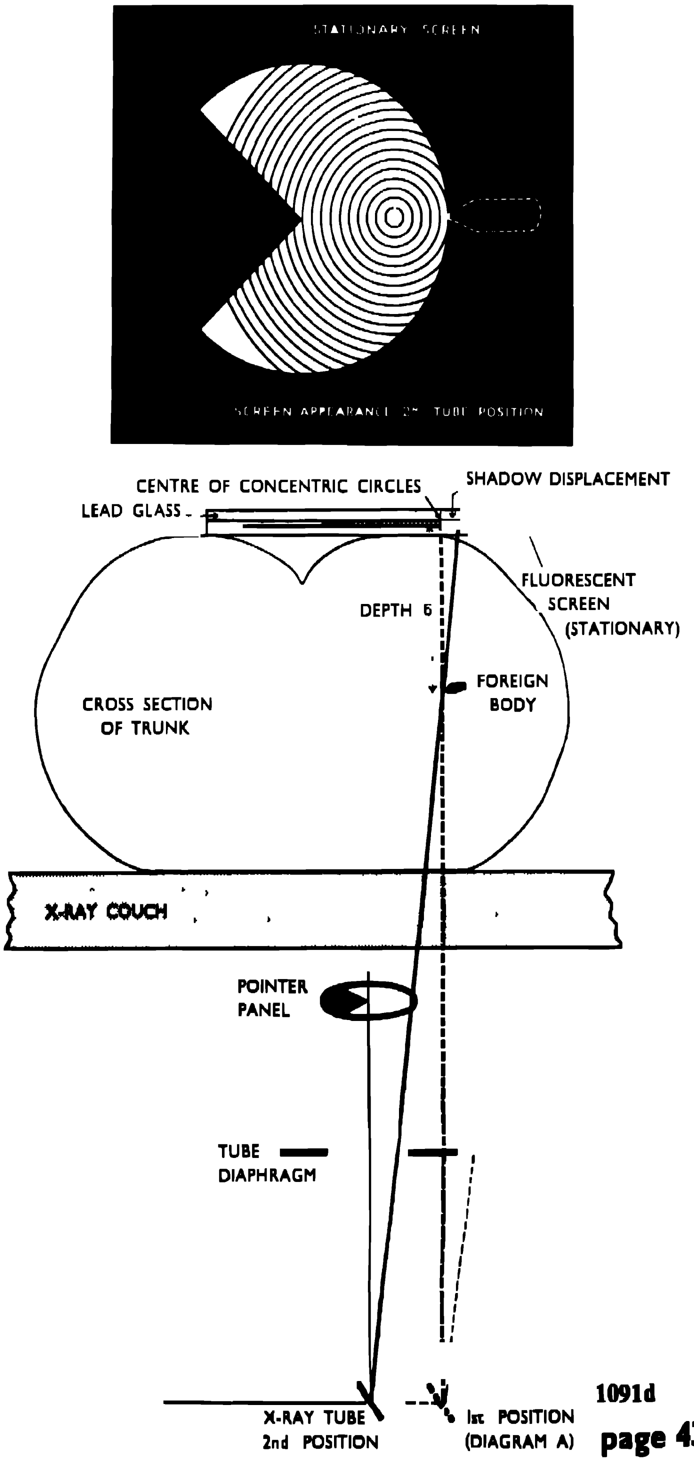
The apparatus consists of a pointer panel placed between tube and patient, and a specially marked fluorescent screen.

Pointer Panel. The pointer panel consists of a piece of lead approximately six inches square and one-sixteenth of an inch thick, mounted on bakelite. An aperture in the lead of the shape of three quadrants of a circle leaves the fourth quadrant as a pointer to indicate the centre of the circle **(1091c)**. Selecting a convenient ratio, for the present purpose eight to one, the radius of the circle should be one-eighth of the distance between the tube focus and the pointer. The panel is placed horizontally on the rectangular diaphragm, or it may be raised on a small platform above the diaphragm in order to reduce the distance between subject and pointer, which has the effect of improving the sharpness of the pointer image on the screen: the selected ratio measurements must, however, be maintained. It is essential for the pointer to be placed directly above the tube focus **(1091c, 1091d, 1091e).**

Fluorescent Screen. A series of black concentric circles one-eighth of an inch apart are drawn, or may be photographed, on a clear celluloid base **(1091c)** and the celluloid placed between the lead glass and the screen *with the side bearing the circles facing the screen* in order to secure the sharpest possible image. Once the correctly cut panel is set in position and the concentric rings prepared *no other measurement is necessary.*



1091c

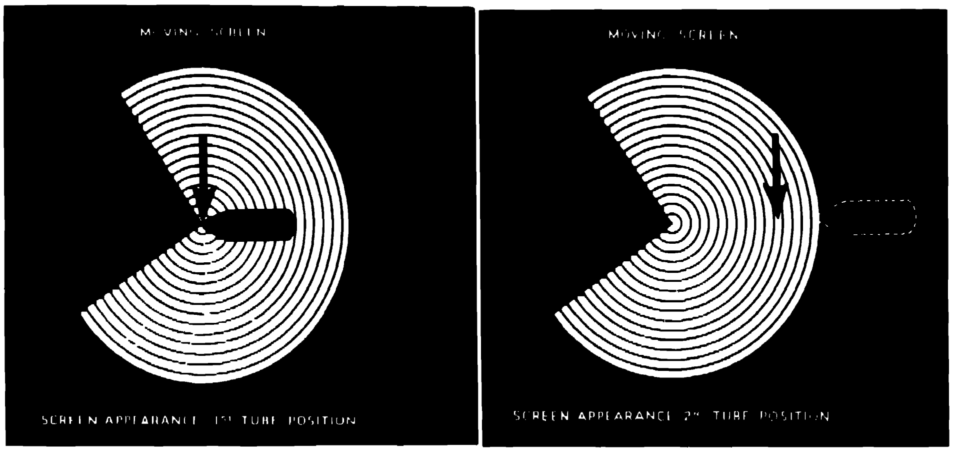


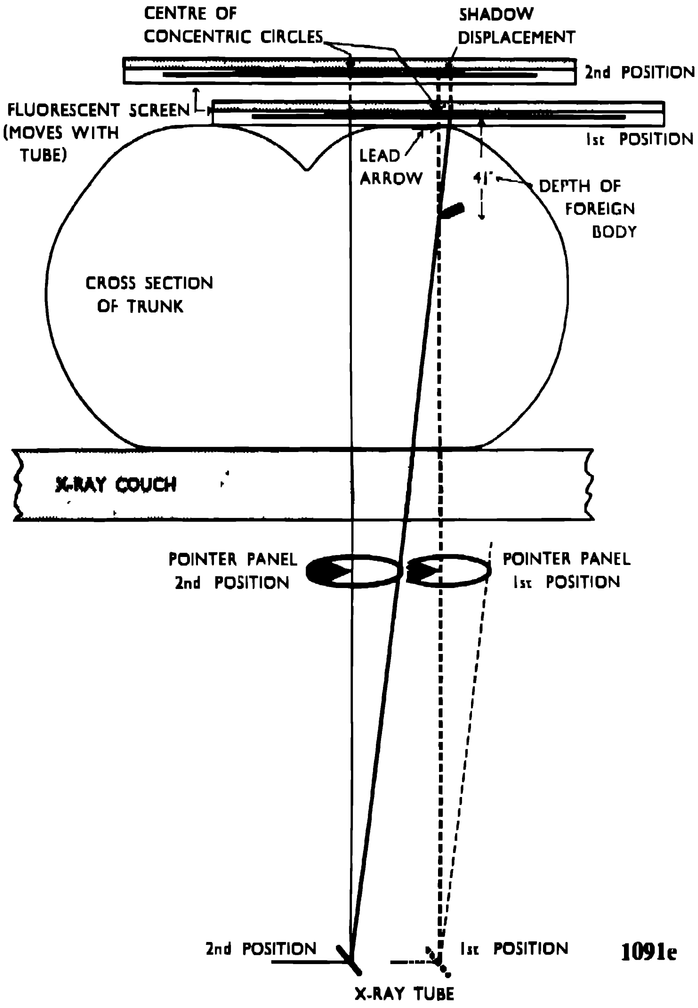
1091d

Foreign Bodies: Localisation of Depth

SCREEN ONLY: SCREEN LOCALISER *(continued)*

In applying this method the procedure varies according to whether the screen rests stationary over the patient **(1091c, 1091d)** or moves with the tube **(1091e)**.





1091e

Stationary Screen. By screen examination the pointer is adjusted to a selected position on the foreign body shadow; the surface position of the foreign body is marked on the skin, and the screen is then placed so that the centre of the concentric circles is over the pointer and the foreign body. Tube focus, pointer, foreign body and the centre of the screen concentric circles are then directly in line **(1091c)**. In this position the centre of the screen circles registers the *first shadow position* of the foreign body **(1091c)**. The tube is then moved until the shadow is on the point of disappearing behind the circumference of the pointer panel aperture **(1091d)**. Thus the *second shadow position* of the foreign body is registered on the screen, the extent of the *movement* of the foreign body shadow being indicated in terms of the number of concentric circles traversed, each of which, by the pre-arranged ratio, is equivalent to one inch in depth of the foreign body—in the case shown 6 inches **(1091d)**.

Moving Screen. As in this instance the screen moves with the tube and pointer panel it is necessary to identify the *first shadow position*, which is done, after centring the pointer to the foreign body, by placing a small lead arrow on the skin surface immediately over the foreign body **(1091e)**.

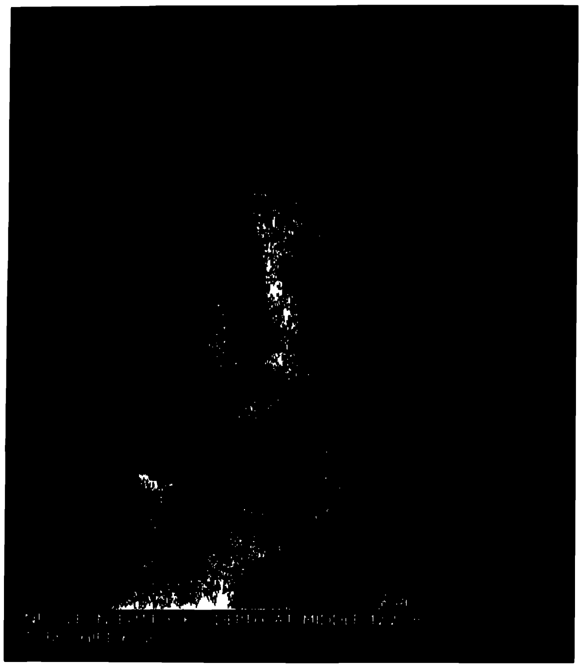
The tube is then moved until the selected point on the foreign body coincides with the edge of the pointer panel aperture and the number of circles is read off *from the shadow of the arrow on the skin* to that of the foreign body at the circumference of the pointer panel, which number in terms of one inch for each circle gives the depth of the foreign body—in this instance $4\frac{1}{2}$ inches **(1091e)**.

For both stationary and moving screen methods movement of the tube at right angles to the direction of the anode is to be preferred to movement along the length of the anode, although movement may be made in any direction.

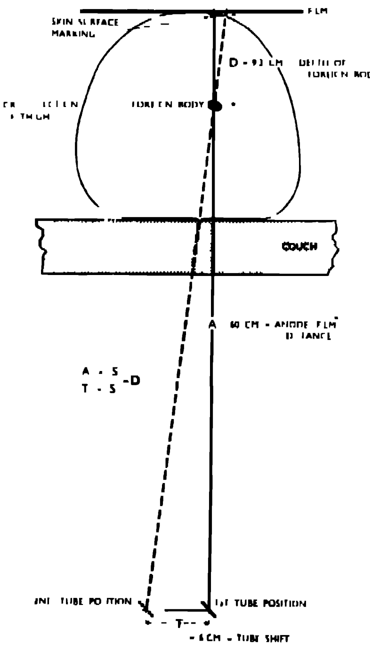
Screen and Film: Similar Triangles

This is a precise method of depth localisation which does not require any special apparatus.

The patient is placed in the position indicated by the surgeon for the removal of the foreign body. By screen examination the under-couch diaphragm is reduced to a small aperture and the tube is centred directly through the foreign body, the position being marked on the skin surface. The diaphragm is then opened and the *first exposure* is made, applying *half* the total normal exposure time. The tube is moved a known distance—for the present purpose 6 centimetres—and the *second exposure* is made on the same film, again at



1092



1092a

1092b

Foreign Bodies: Localisation of Depth

SCREEN AND FILM: SIMILAR TRIANGLES *(continued)*

half the normal time, the total normal exposure time being thus completed **(1092, 1092b)**. The anode-film distance is noted.

On viewing the processed film the distance between the foreign body shadows is measured (using the same relative point on each) and from the data now known the depth of the foreign body may be calculated by applying the formula:—

$$\frac{A \times S}{T + S} = D,$$

when
A = anode-film distance;
T = tube shift;
S = shadow shift; and
D = depth of foreign body;

in the case shown **(1092a)**

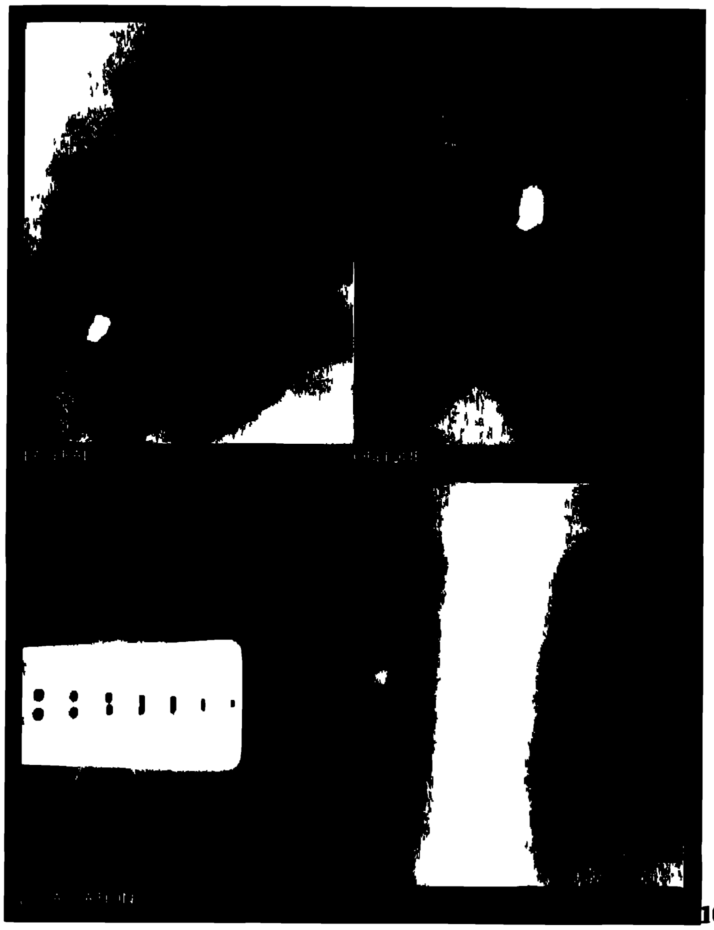
$$\frac{600 \times 11}{60 + 11} = 93 \text{ millimetres.}$$

The table on page 430 will be found useful: the calculations are in respect of a tube shift of 6 centimetres and cover a range of anode-film distances from 50 centimetres to 80 centimetres, and shadow shifts from 0·5 millimetres to 20 millimetres, and by its use a further reduction in the localisation *time* factor may be made. The measurement obtained is the depth of the foreign body below the mark on the skin surface, or from the upper skin level on a curved surface.

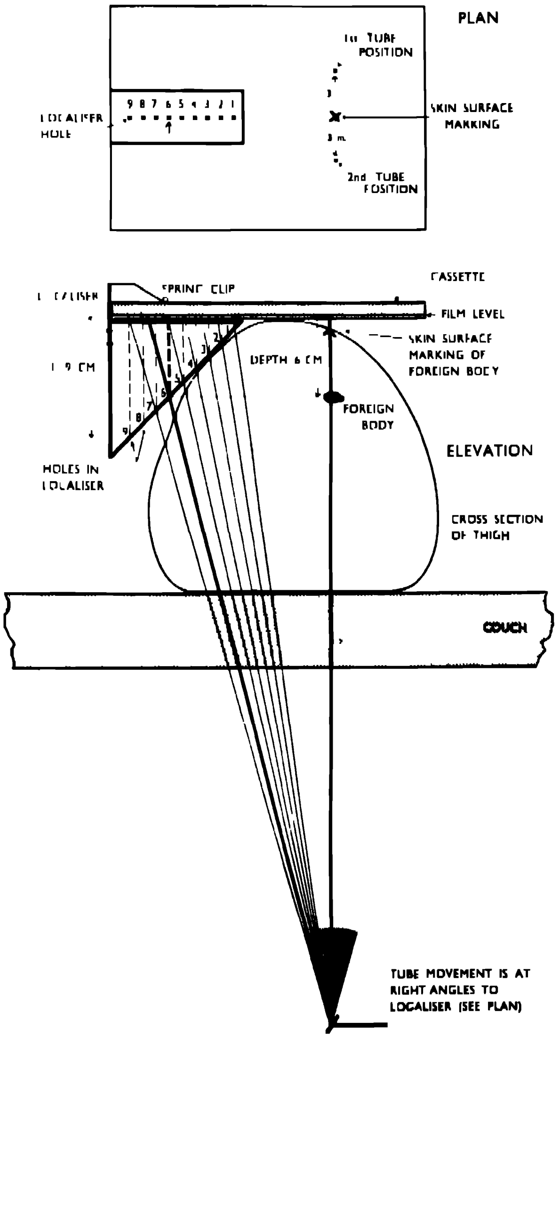
Note—All calculations are shown in millimetres to avoid confusion in making the three measurements.

It should be noted that in applying shadow-shift technique the two exposures may be made on separate films in order to provide also a pair of stereoscopic radiographs. When this is done it is imperative that the second film should be exposed in precisely the same position as that occupied by the first film.

After processing and drying the films it may be possible to measure the shadow displacement by placing one film over the other and so noting the distance between the shadows. If, however, the films are too dense for this method to be followed, a piece of celluloid of similar size is placed on each in turn, and with a stiletto the same point on each foreign body shadow is pricked on to the celluloid, the distance between the two points being measured.



1092c



1092d

Foreign Bodies: Localisation of Depth

Screen and Film: Parallax

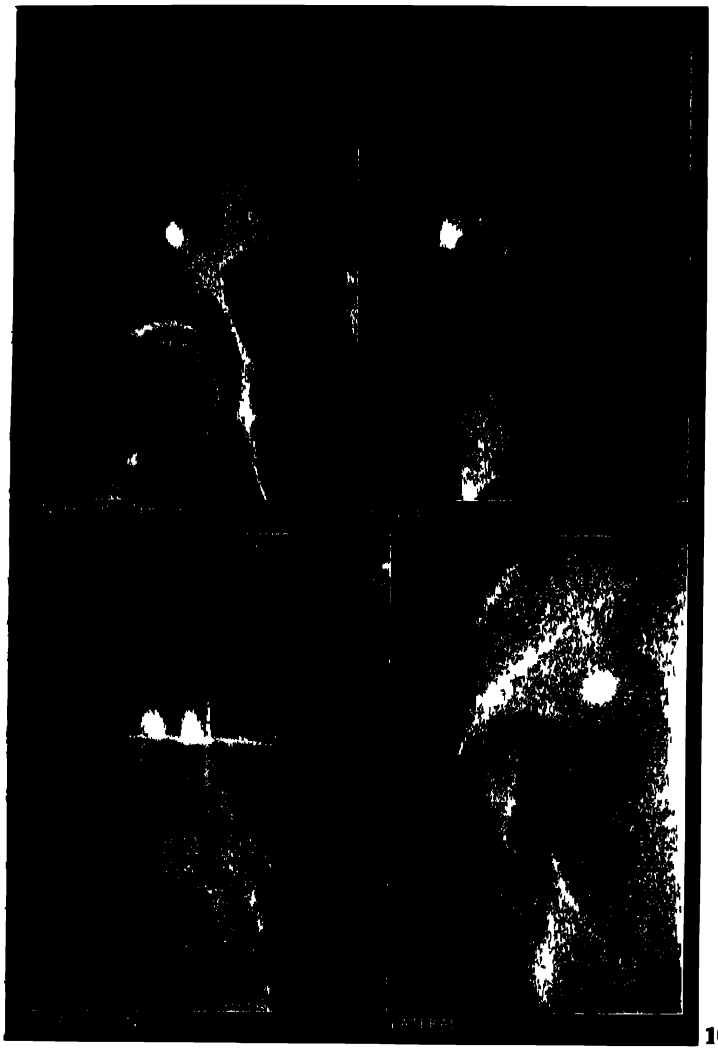
Various apparatus has been made for the purpose of applying the principle of parallax to the localisation of foreign bodies, and the following is chosen for its simplicity of application. This also is a precise method of localisation.

The localiser is made of light metal in the form of a triangle of which the hypotenuse is faced with a brass plate having holes drilled at intervals corresponding to graduated depths in centimetres from the film level. A metal clip allows the film or cassette to be placed horizontally over the localiser holes and the subject **(1092d)**.

APPLICATION

The patient is placed in the indicated operative position for the removal of the foreign body. Screening is applied and the position of the foreign body marked on the skin surface, after which the tube diaphragm is opened sufficiently to cover the whole of the localiser, which is then placed in position with the holes in line with the skin marking and with a cassette in the clip, a spirit level being used to ensure it being horizontal **(1092d)**. A convenient anode-film distance is employed, and although an exact measurement is not necessary the tube shift should be approximately one-tenth of the anode-film distance — for example, 6 centimetres at 60 centimetres, and the two exposures are made from points equidistant from, and on each side of, the centring point. It is important that the tube movement should be at right angles to the long axis of the localiser; see plan **(1092d)**.

After processing the film the shadow shift of the foreign body is measured, using dividers, and an equal shadow shift cast by a localiser hole is identified **(1092c)**. It is obvious that the foreign body is at the same depth as the hole causing the equal shadow shift: in the elevation view **(1092d)** it is shown to be 6 centimetres. The holes may be numbered from one onwards, to indicate the depth scale on the radiograph, and any intermediate hole measurements may be easily calculated. In the localisation radiograph **(1092c)** the foreign body was shown to be 7 centimetres deep, which depth the removal operation proved to be correct.



1093

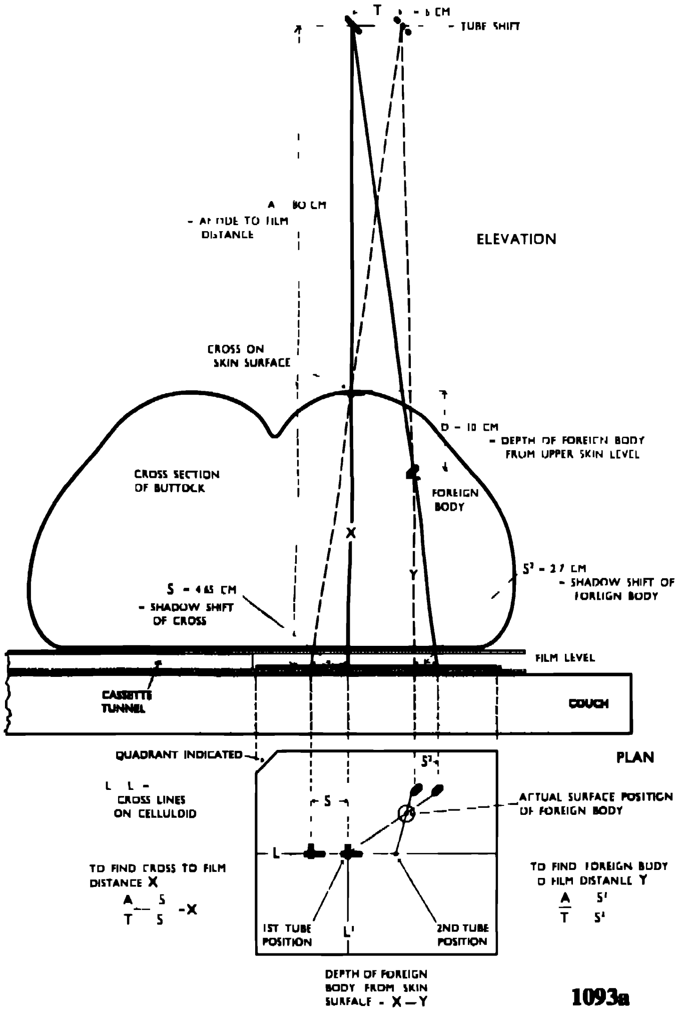
Foreign Bodies: Localisation of Depth

Film only: Similar Triangles

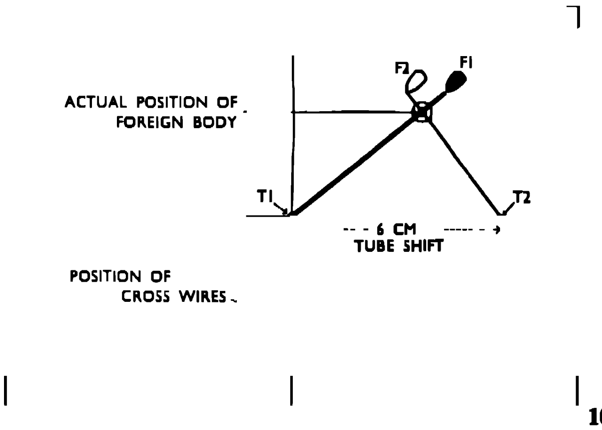
When facilities are not available to permit of the skin surface marking being made by screen examination with the *under-couch tube*, as may well occur in an emergency hospital equipped only with a small mobile unit, or in the operating theatre, the method of similar triangles becomes a little more complicated. In such cases the following technique employing the *over-couch tube* may be applied with advantage, and it may also be found of use in dealing with the thicker parts of the trunk of a large subject where a shadow-shift exposure would be too diffuse for accurate measurement, in which cases the Potter-Bucky diaphragm is employed **(1093)**.

There are two distinct investigations, (a) estimation of the skin surface position of the foreign body; and (b) calculation of the depth of the foreign body. These are first discussed separately and are later combined in the *general procedure*.

(a) To find the surface position of the foreign body a metal cross or cross-wire frame is placed on the patient, the direction of the cross-arms being indicated on the skin: shadow-shift technique is applied, the first centring position being over the intersection of the cross-wires and the second a known distance along one arm of the cross-wires, for example, 6 centimetres **(1093b)**. This latter position is marked on the developed film and the four points—two tube positions and two on the foreign body shadows—are joined by two lines which intersect to show the *actual* position of the foreign body in relation to the cross-wires, and this data may be transferred to the patient. The four points may be designated T_1, T_2 and F_1 and F_2 **(1093b)**.



1093a



1093b

(b) Depth calculation by the method of similar triangles has already been discussed, but it should be remembered that when the over-couch tube is employed the film is

FILM ONLY *(continued)*

placed adjacent to the skin surface which is the more *remote* from the foreign body, modification of this technique being, therefore, necessary.

On combining these two investigations the following general procedure may, after a reasonable amount of practice, be applied quickly and accurately, it being possible to complete the entire process in not more than six minutes.

Note—The *figures* of S^1 and S^2 (1093a) should not be regarded as a part of the calculation.

GENERAL PROCEDURE

It is essential to use a cassette tunnel (1093a), on which the patient is placed in the correct position for the removal of the foreign body. A lead cross having arms of irregular length is placed on the skin surface within the supposed foreign body region, as indicated by the initial films, to show the tube centring point, and is strapped in position with one cross arm pointing in the pre-arranged direction of the tube movement. If the tissues are damaged the cross is mounted on a washed-off celluloid and placed over the piece of gauze covering the wound, and the cross to upper skin surface distance is noted. Cross-wires mounted in a wooden frame of convenient size may be used in place of the small lead cross, one quadrant of the frame bearing a lead quadrant indicator for guidance as to the anatomical direction of the cross-wires.

The tube is centred to the cross and the *first exposure* is made, applying half the normal full-exposure time. The tube is moved 6 centimetres in the direction of one arm of the metal cross and the *second exposure* is made on the same film, completing the normal full exposure time (1093a).

Leaving the cross in position on the patient the film is processed, the radiograph being available one minute later.

The moisture having been removed from the film by compressing it for a few moments between blotting paper, it is then placed on the plate glass over the viewing box. The film shows two shadows of the cross and two of the foreign body: the two shadows produced by the *first exposure* may be easily identified by their greater clarity, or for the first exposure a lead arrow may be placed opposite the cross. A piece of lined celluloid is placed over the film with the cross-line intersection over the *first* shadow of the lead cross which, as already stated, is the more clearly shown. Using a stiletto, the celluloid is marked over a similar point on each foreign body shadow and also at the centre of the *second* shadow of the cross. The relative position of the celluloid to the film is also indicated in order that the celluloid may later be placed in the correct position on the patient. This is facilitated by using a cross having arms of unequal length or by the marking of one quadrant of the mounted cross-wired frame. From the marked celluloid it is now possible to obtain the required information, as follows:—

To Calculate the Depth of the Foreign Body, the marked celluloid is placed over a ruler and measurements of the shadow-displacement of the foreign body and of the cross are noted. By applying the formula:—

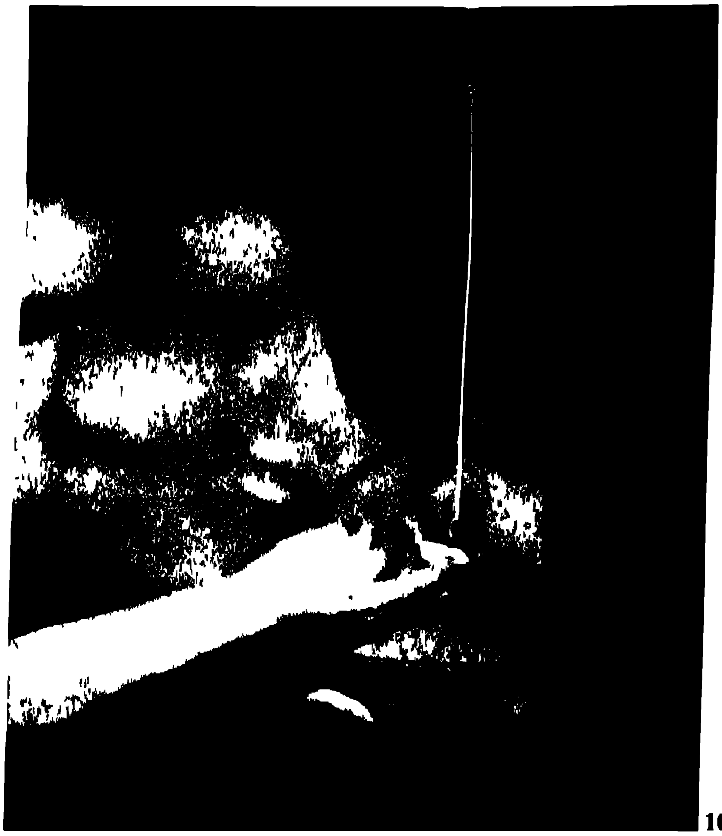
$$\frac{A \times S}{T + S} \quad D,$$

as previously discussed, or by reading the two distances on the localisation chart on page 430, the distance X, of the cross, and Y, of the foreign body, from the film are known (1093a). It should be remembered, however, that these are not measurements of distance between foreign body and near skin surface, such as is the case when the under-couch tube is employed, and that it is now necessary to deduct the foreign body to film distance, Y, from the cross to film distance, X, to ascertain D, the depth of the foreign body below the skin surface (1093a).

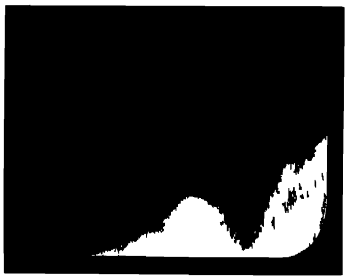
To Locate the Skin Surface Position of the Foreign Body the second tube position is marked on the celluloid cross line, measuring the applied distance of 6 centimetres from the intersection of the lines and in the direction *opposite* to the displacement of the second cross shadow.

As previously described, the four positions, first tube centre to first shadow-shift point and second tube centre to second shadow-shift point are joined diagonally by lines which, at their point of intersection, show the skin-surface position vertically over the foreign body in relation to the recorded position of the lead cross or cross-wires (1093a). The celluloid is pierced at this point and then placed on the patient in the correct anatomical position (indicated) with the intersection of the cross lines over the cross on the skin. The position of the foreign body is marked on the skin through the hole in the celluloid and the surgeon is given the depth of the foreign body at this point. When a curved skin surface is encountered the depth measurement is, of course, indicated from the highest skin level (1093a).

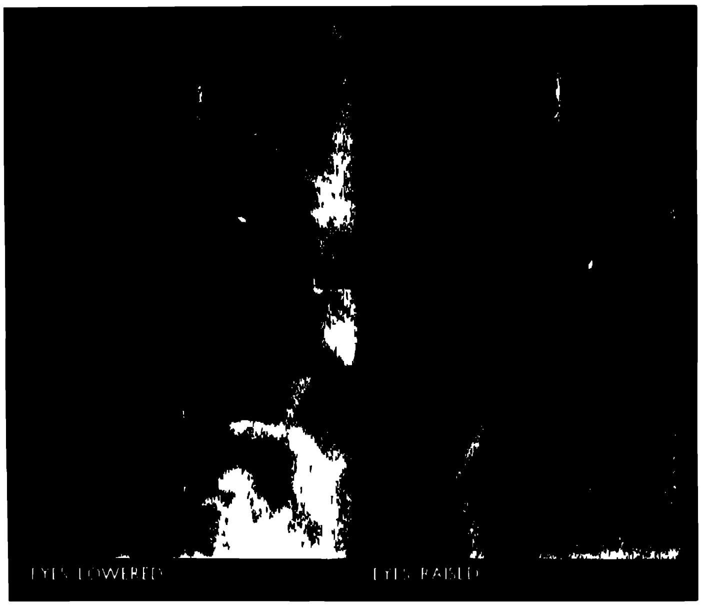
In (1093) the surface position of the cross-wires almost coincides with that of the foreign body, which was found to be 10 centimetres below the skin surface, this measurement being later confirmed.



1094



1094a



1094b

Orbital Cavity

GENERAL OBSERVATIONS

Successful eye localisation requires meticulous care and considerable practice by a selected method, and only a limited number of X-ray workers are likely to have the opportunity of becoming proficient in this specialised branch of radiography.

The identification of a foreign body in the orbital cavity—in the eyeball or in close proximity thereto—is only possible when the body is opaque, the examination involving two stages, (*a*) confirming its presence; and (*b*) determining its precise position.

Exposures should be made with the head clamped in position—true lateral or occipito-mental, as the case may be.

Soft tissue films showing good detail are essential: intensifying screens used should be free from any blemishes likely to be confused with foreign body shadows.

The special cassette holder employed has fine cross-wires attached, their point of intersection being adjusted to the centre of the pupil when the sight is directly forward and level, or outside the eyeball, according to the technique applied. The holder may be constructed to accommodate a film large enough for two exposures, the cassette being moved for the purpose, with one half protected in turn **(1094b)**.

An anode-film distance of 40 inches is generally used: while this is usually the maximum possible under ordinary conditions, it is still sufficient to give negligible distortion to near-film shadows.

For the purpose of foreign body localisation the eye is regarded as being a sphere having a diameter of 24 millimetres.

CONFIRMATION OF PRESENCE OF A RADIO-OPAQUE FOREIGN BODY

With the patient in the lateral position two exposures are made on a whole plate cassette, one exposure with the eyes raised and the other with them lowered.

A typical film thus exposed **(1094b)** reveals an opaque foreign body in two positions in relation to the cross-wires, and indicates also that it is within the orbital cavity, and therefore either in the eyeball or in one of the muscles of the eye. With this information the precise localisation of the foreign body may be determined.

To identify a foreign body in the anterior portion of the eyeball a small dental film may be used, it being held, during exposure, firmly on the nasal aspect of the eye and as nearly as possible parallel to the median plane of the head **(1094, 1094a)**.

CONFIRMATION OF PRESENCE OF A RADIO-OPAQUE FOREIGN BODY *(continued)*

EXPOSURE FACTORS

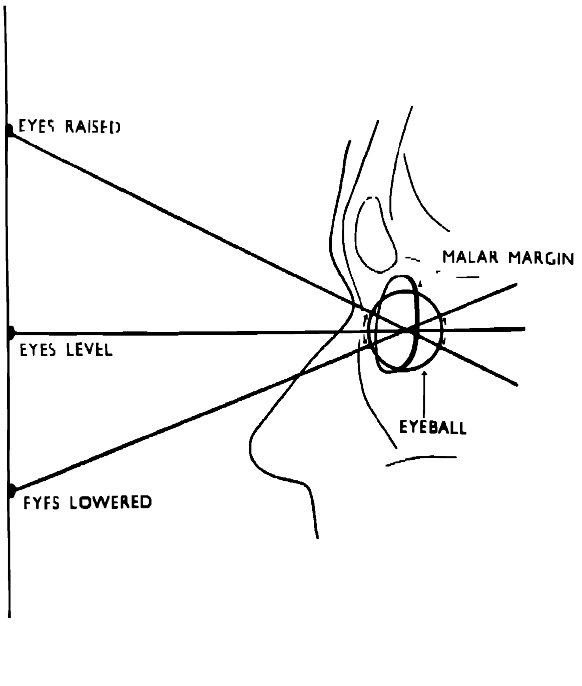
kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
40	84	50	30″	Ilford Special Dental		

Small Cone.

DETERMINATION OF THE PRECISE POSITION OF A FOREIGN BODY

There are two main methods, (*a*) determining the position of the foreign body relative to the centre of the eye, for which no special apparatus is required; and (*b*) determining the depth of the foreign body from the plane tangential to the centre of the cornea, and charting the three dimensions. Of the several methods employed under (*b*) the two here mentioned necessitate, respectively, the use of a point and cross localiser and localisation spectacles.

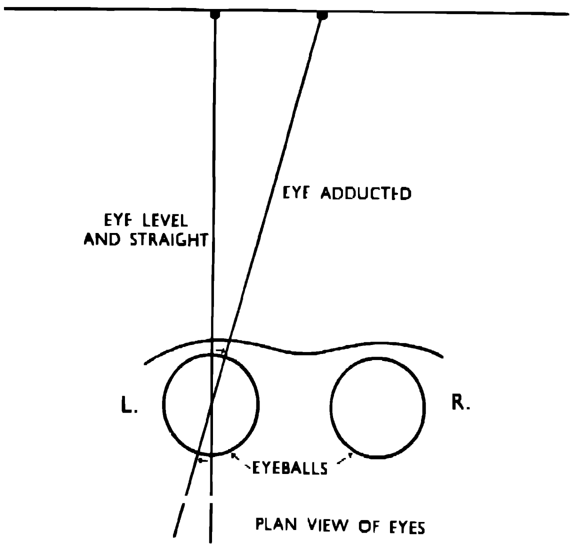
It should first be ascertained whether the patient is able to keep both eyes fixed on some given mark or object, for which purpose a black disc placed at eye level and directly in front of the eyes, or immediately over-head when the patient is supine, is usually employed: this is termed *ocular fixation.* Consideration should be given to any impairment of mobility, choice of technique indeed, being governed by the degree to which mobility is affected.



1094c

DETERMINING THE POSITION OF THE FOREIGN BODY RELATIVE TO THE CENTRE OF THE EYE

It will be clear from the diagram (1094c), representing the eye from the lateral aspect, that if a foreign body is anterior to the centre of the eye it will move upward when the eye is raised, and if posterior will move downward: there will be no apparent change of position of a circular body at the centre, while the re-orientation of an irregular outline will be obvious.



1094d

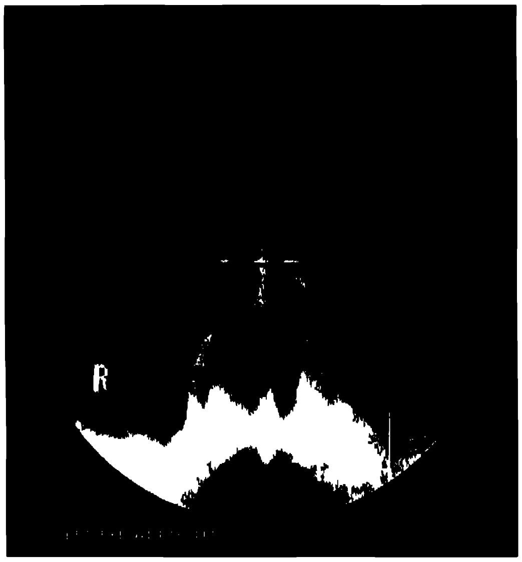
Similarly (1094d), the foreign body in the anterior hemisphere will turn in direction with the eye when the eye is adducted, that in the posterior hemisphere moving in the opposite direction, while the body at the centre will remain apparently stationary.

Five films are therefore exposed to show the displacement of the shadow about the centre of the eye.

The patient should look steadily at some predetermined mark or small object, which as previously mentioned, usually takes the form of a prominent black disc placed, at the level of the eyes, on wall or ceiling according to whether vertical or horizontal technique is employed.

For postero-anterior exposures the frame supporting the fine cross-wires is placed with the *point of intersection* of the wires in line with the *centre* of the pupil, while for lateral exposures the *horizontal* wire is adjusted to the *level* of the centre of the pupil.


1095


1096

DETERMINING THE POSITION OF THE FOREIGN BODY RELATIVE TO THE CENTRE OF THE EYE *(continued)*

The head is carefully immobilised before the following two postero-anterior and three lateral exposures are made:—

(*a*) Postero-anterior, with eyes on disc **(1095)**:

(*b*) Postero-anterior, with eyes adducted (turned toward the nose) **(1096)**:

(*c*) Lateral, with patient looking at disc **(1097)**:

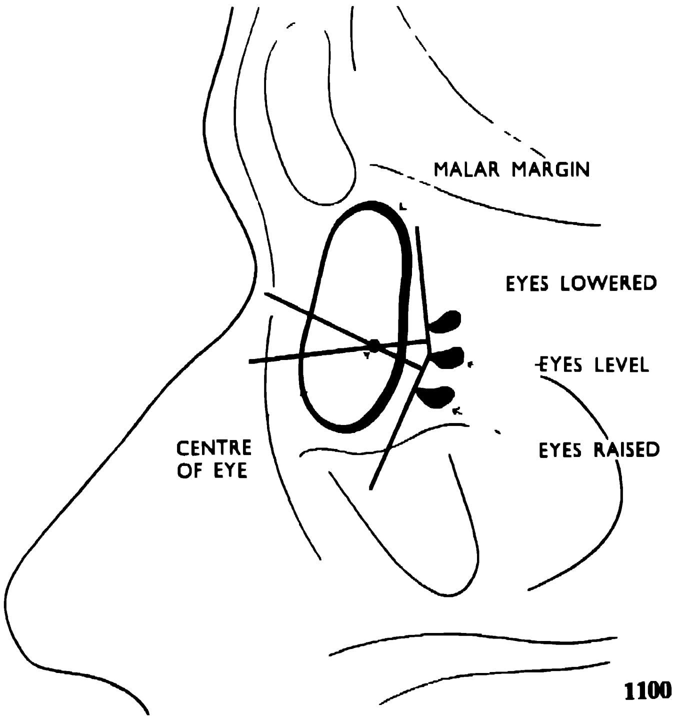
(*d*) Lateral, with eyes raised **(1098)**:

(*e*) Lateral, with eyes lowered **(1099)**.

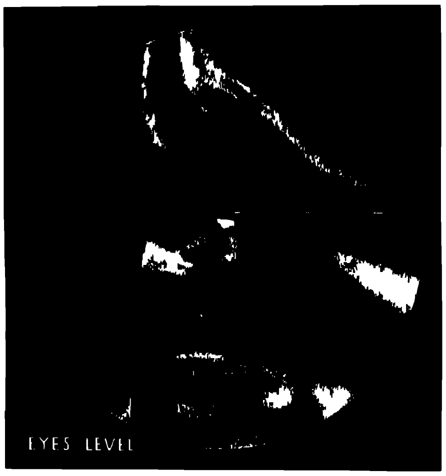
These five films enable the body to be localised, whether it be in the eyeball or in the adjacent muscles.

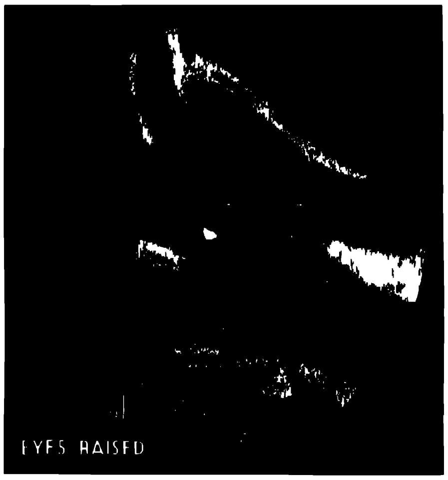
TO COMPLETE LOCALISATION

From the three lateral views a tracing is made showing the three shadows of the foreign body; straight lines are



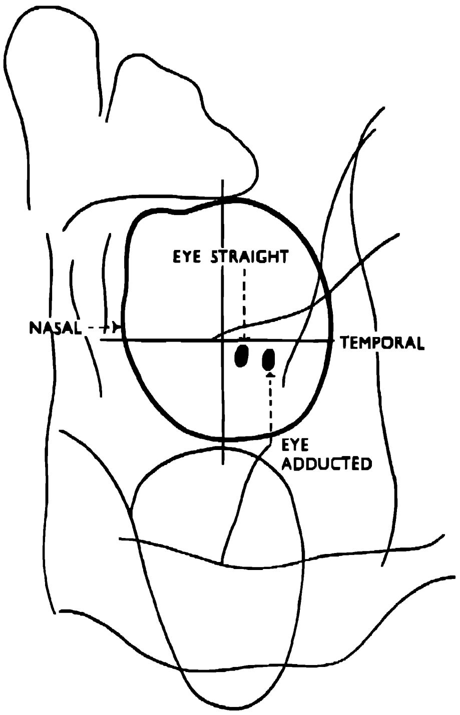
1100


1097


1098


1

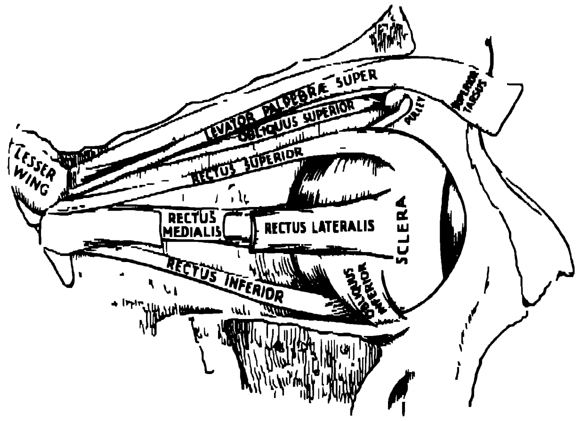
TO COMPLETE LOCALISATION (*continued*) drawn to join them and, these being chords of the arc described by the body during eye movement, lines bisecting them at right angles will, at their point of intersection, indicate the centre of the eyeball *if the point of intersection falls slightly anterior to the malar border of the orbit* **(1100)**, in which case the foreign body is indicated as being *in the eyeball.* If, however, the point of intersection should be remote from the malar border it will be an indication that the foreign body is not in the eyeball but in the *surrounding tissue or muscles* **(1104)**.



1101

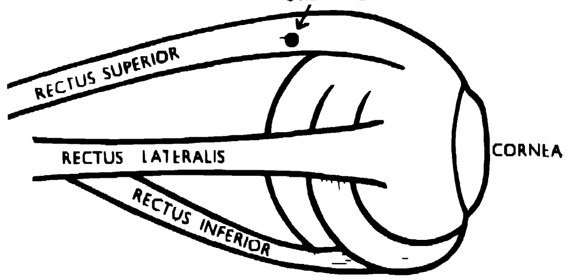
A second tracing, prepared from the two postero-anterior films, will enable the lateral movement of the foreign body to be plotted, and will disclose its antero-posterior position relative to the centre of the pupil, indicated by the intersection of the cross-wires **(1101)**.

The five films, therefore, will be found to disclose the latitude and longitude, as it were, of the foreign body.



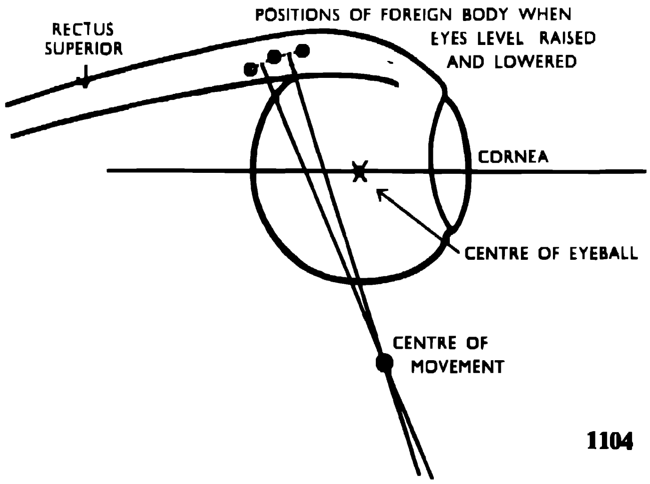
THE MUSCLES OF THE RIGHT ORBIT
LATERAL ASPECT **1102**

When the foreign body is shown by the tracing to be *outside* the eyeball, the particular muscle in which it is situated may be identified by reference to the anatomical diagram showing the muscle attachments of the eye **(1102)**.



1103

Two diagrams show **(1103)** a foreign body (in this case a pellet from an airgun) in the superior rectus muscle, and **(1104)** its movement, from the lateral aspect, in the three eye positions and also its centre of movement in relation to the centre of the eye.



1104

Although this method has certain drawbacks, a knowledge of its possibilities will allow it to be applied, in part, when other methods have been found to be inconclusive because of the possible variation in the size or shape of the eye.

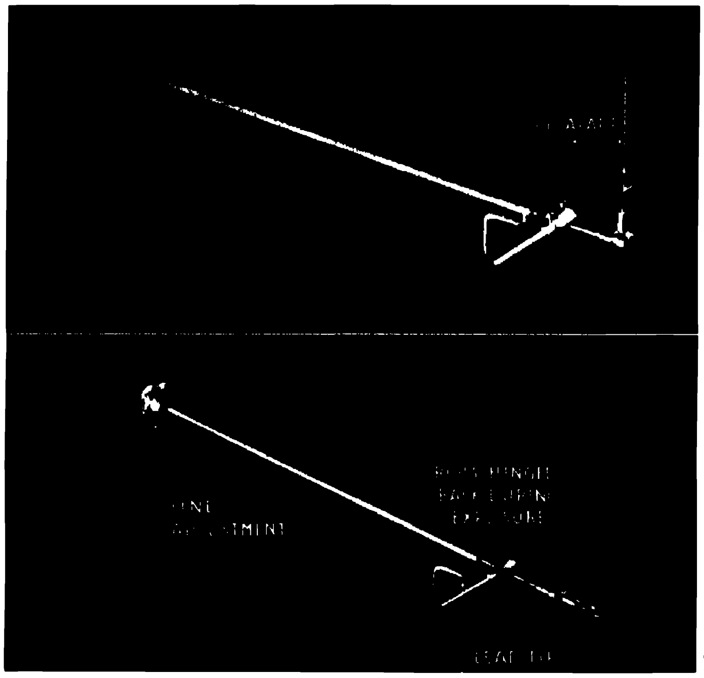
DETERMINING THE DEPTH OF THE FOREIGN BODY FROM THE PLANE TANGENTIAL TO THE ANTERIOR MARGIN OF THE CORNEA

Two methods are discussed.

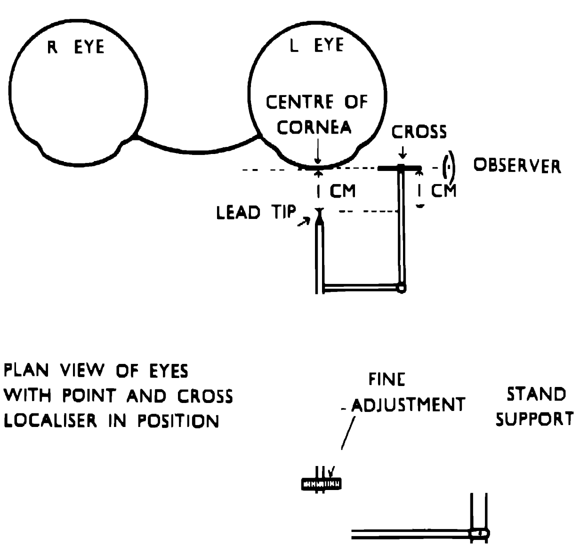
POINT AND CROSS LOCALISER

This eye localiser is a simple device for locating the level of the anterior margin of the eyeball. In operation it is clamped to the stand, and consists of a holder carrying a lead-tipped pointer and a small metal cross fixed one centimetre apart longitudinally and about 4 centimetres laterally, and moving in the holder by means of a fine screw adjustment (**1105**).

The patient, having been immobilised, gazes at the given mark. The lead point is brought directly in the line of vision and moved toward the eye until the metal cross is seen from the lateral position, edgewise, to coincide with the anterior level of the cornea: the lead point is then one centimetre from the centre of the cornea (**1106**). The metal cross is then turned on its hinged base away from the eye field and, using cross-wires on the cassette, two lateral exposures are made from a suitable anode-film distance of from 50 centimetres to 80 centimetres and with a total tube shift of 6 centimetres—in turn, 3 centimetres to each side of the centre point (**1107**). With the assistance of a pair of dividers and a piece of celluloid marked to show the position of the cross-wires the shadow displacements of foreign body and lead tip are taken from the film, and also their displacements away from both vertical and horizontal cross-wire lines. From these measurements the position of the foreign body may be determined by calculation, the use of a slide rule, or by plotted diagram This latter method is shown (**1108, 1109**).

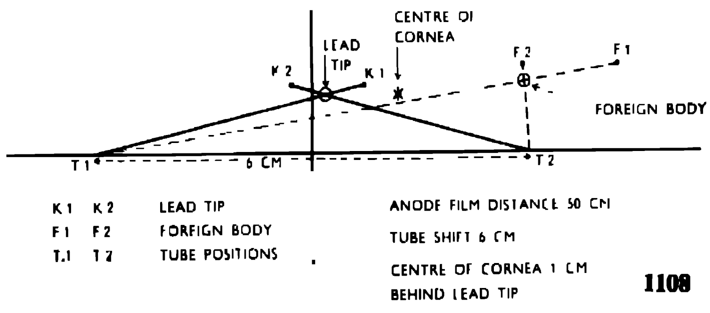


1105



1106

1107

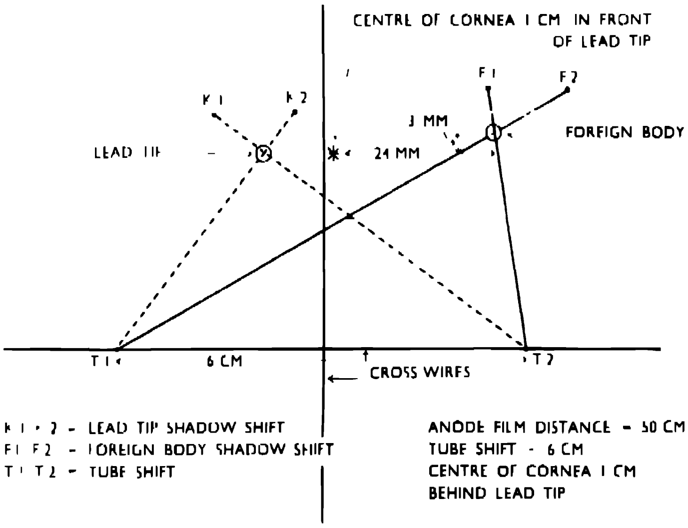


1108

POINT AND CROSS LOCALISER (*continued*)

The relative positions of the foreign body and lead tip to the cross-wires in both views are transferred to the piece of celluloid **(1107, 1108)**.

The tube shift is shown along the horizontal cross-wire T_1 and T_2 and from these two points lines are drawn to the foreign body shadows, T_1 to F_2 and T_2 to F_1, their point of intersection giving the precise position of the foreign body in relation to the cross-wires. The lead tip shadows are similarly joined to give the position of the lead tip. At one centimetre from the lead tip shadow in a line parallel to the horizontal cross-wire and in the direction of the shadow of the foreign body, a mark may be made to indicate the position of the anterior margin of the cornea, the distance from that point to the foreign body shadow being the depth of the foreign body from the film plane tangential to the cornea **(1108, 1109)**.

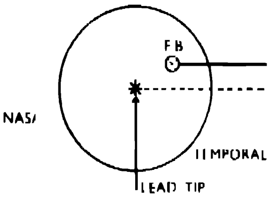


1109

It should be noted that in **(1108, 1109)** the terms F_1 and F_2 have been reversed as compared with similar references in the text.

The *lateral* displacement of the foreign body toward the nasal or temporal aspect is indicated by the difference between calculated distance from the film of the foreign body and of the lead tip: should the foreign body show the greater distance, displacement will be toward the nasal aspect, its showing the lesser distance indicating displacement of the foreign body toward the temporal aspect **(1110)**.

Two examples of this technique are included, **(1108)** showing the foreign body to be ***within the eyeball***, and **(1109, 1110)** showing it to be *outside the eyeball* but within the orbital cavity.



FOREIGN BODY 5·9 MM TO TEMPORAL SIDE OF CENTRE OF CORNEA
1 MM ABOVE CENTRE OF CORNEA
DEPTH 24 MM - OUTSIDE EYEBALL

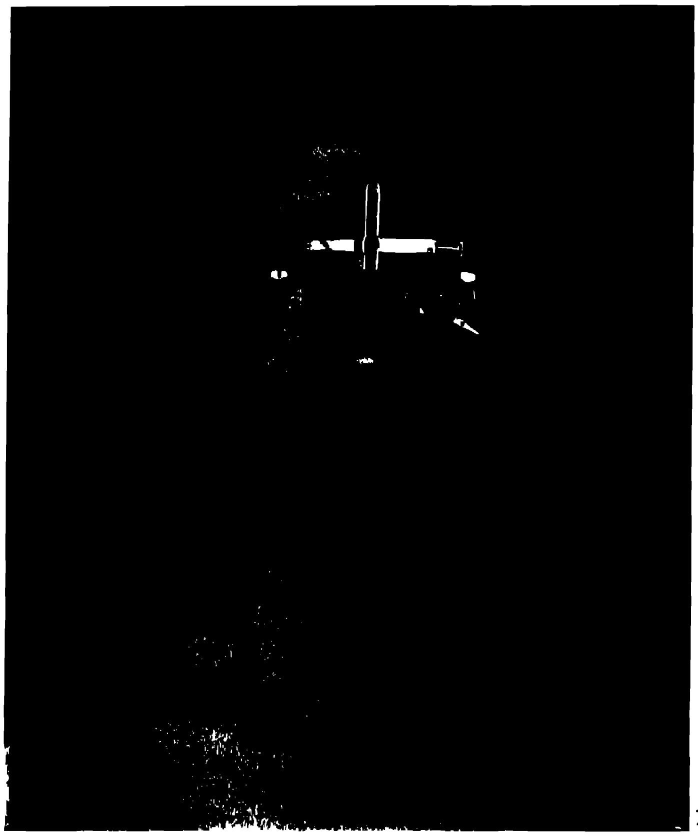
1110

It should be noted that the cross-wires attached to the cassette holder are the more suitably placed when appearing outside the orbital cavity, as in **(1109)**, in which position they are clear of foreign body shadows within the eyeball.

This method of eye localisation is in some respects similar to the Sweet method, in which a ball is brought into contact with the cornea and then by means of a spring is displaced one centimetre away from the eye, thus providing on the films an opaque indicator at a known distance from the cornea, from which film data, with the aid of special charts, calculation is made of the position of the foreign body within the orbital cavity.

The principle of this method of localisation has been incorporated, 1943, in a complete unit for eye localisation. This apparatus includes a small X-ray set mounted in the correct position for taking the shadow-shift films. Data are calculated with the aid of a localisation chart.

SPECIAL NOTE—It will be appreciated that the diameter of a section of a sphere diminishes as its distance from the centre increases, and therefore in demonstrating the position of a foreign body which may appear within the disc presented by the eyeball it is necessary to determine the depth of the section through which the foreign body is apparently seen. Reference should be made to **(1112a)**, page 445.



1111

1111a

Foreign Bodies: Orbital Cavity

SPECTACLE METHOD

After determining that an opaque foreign body is present in the orbital cavity and confirming that ocular fixation, described earlier, is possible, the spectacle technique follows a course which, for convenience, is discussed in the following stages:—

(a) Taking the shadow-shift film:

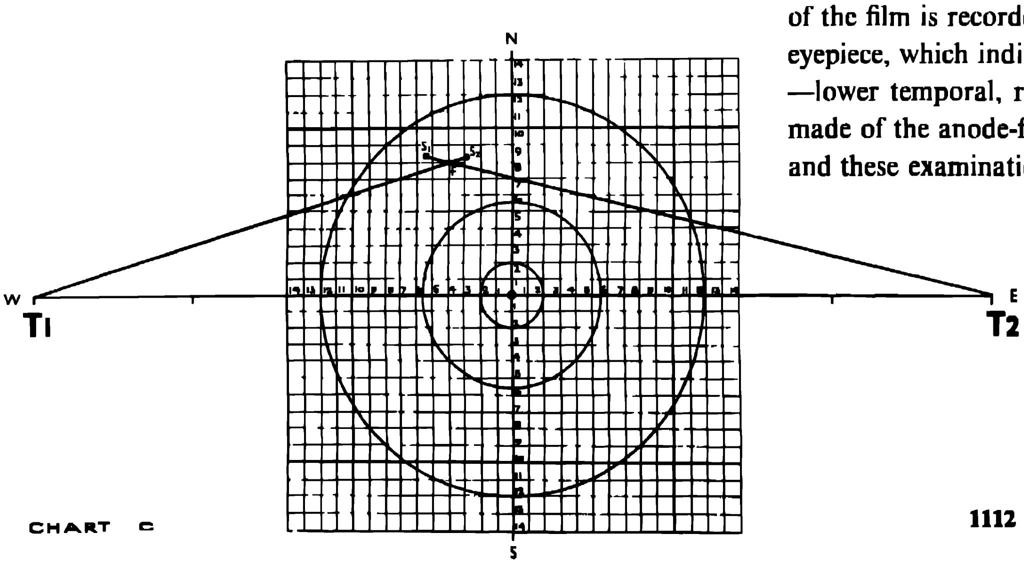
(b) Estimating the surface position of the foreign body:

(c) Calculating the depth measurement:

(d) Charting the actual position of the foreign body.

(a) *Taking the Shadow-Shift Film.* A specially designed form of spectacle frame is used, having adjustable nose piece and cross-wired eyepieces, which latter, by means of a slide with screw control, can be lowered to the level of the eye, the eyepiece serving as a rest for the film during the exposure. When correctly in position the eyepiece is parallel to the couch and to the direction of the tube movement, with the raised indicator vertically over the intersection of the cross-wires (**1111a**).

The patient's head is immobilised, with the neck resting on a sandbag and the eyes fixed on the over-head mark. The eyepiece over the eye being examined is adjusted so that the point of intersection of the cross-wires is immediately over the pupil; the eyes are then closed, the eyepiece is lowered until it touches the eyelid, gentle compression is applied, and by means of screening the tube is centred to the point of intersection of the cross-wires with the raised indicator immediately above; the diaphragm is then opened, the film—dental size—is rested upon the eyepiece, the sound eye again looks at the over-head mark, and the two tube-shift exposures are made on the one film, the tube positions being 3 centimetres on each side of the centring point and in line with one of the cross-wires. A small weight placed on the film serves to maintain good contact (**1111a**). The position of the film is recorded by a small metal projection on the eyepiece, which indicates a particular quadrant of the eye —lower temporal, right or left: careful record should be made of the anode-film distance and tube shift employed, and these examinations will be facilitated if conditions are standardised as far as possible. After processing the film the presence of a foreign body in a particular quadrant is noted.



1112

Foreign Bodies: Orbital Cavity

SPECTACLE METHOD (*continued*)

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
75	160	97	26″	Ilford Standard Dental		
75	16			Ilford Occlusal	*Tungstate	

* When the occlusal cassette is employed the thickness of the front of the cassette and of the front screen should be deducted from the foreign body depth measurement.

(b) *Estimating the Surface Position of the Foreign Body.* The film distance of the foreign body shadows from the cross-wires is measured in millimetres and with a sharp pencil the position of the foreign body is marked on the Chart C **(1112)**, which is lined in units to represent millimetres.

ELEVATION

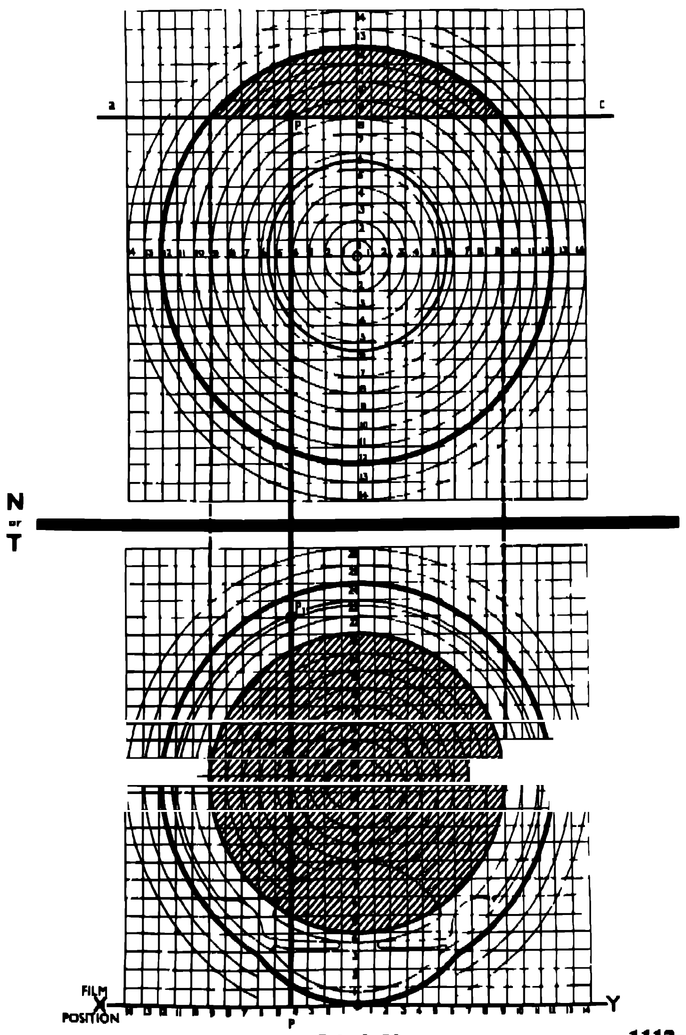


CHART D PLAN **1112a**

The four points, tube-centre positions T_1 and T_2 to foreign body shadows S_1 and S_2, are joined, the lines intersecting to give the actual position of the foreign body as seen from the anterior viewing aspect (elevation) of the eye **(1112a)**. The points S_1 and S_2 are those referred to earlier as F_1 and F_2.

(c) *Calculation of Depth.* The film shadow shift of the foreign body is measured, and by applying the formula

$$\frac{A \times S}{T + S} = D,$$

or by referring to the table of depths, page 446, the depth of the foreign body in the case shown **(1112a)** is

$$\frac{550 \times 2{\cdot}5}{60 + 2{\cdot}5} = 22 \text{ millimetres,}$$

this being its distance from the film plane tangential to the cornea.

(d) *Charting the Actual Position of the Foreign Body.* It will be seen that the Chart D **(1112a)** embraces two diagrams, representing elevation and plan views of the eyeball respectively, with the exposure position of the film indicated by the line XY in the latter view. The position, P, of the foreign body is transferred from the Chart C **(1112)** to the elevation diagram, and through P a horizontal line a-c is drawn of which the part within the circumference of the circle represents the diameter of the section of the eye in which the foreign body lies. From the points at which a-c cuts the circumference perpendiculars are dropped to d-e, the major axis of the lower diagram, and through the feet of the perpendiculars the plan view of the section is completed (shaded).

From the point P (elevation) a perpendicular is dropped to the plan film line, XY, which it meets at P and from this point the ascertained depth of the foreign body from the film P to P_1, is set off along the perpendicular, P_1 being the actual position of the foreign body. When P_1 is within the shaded section the foreign body is actually within the eyeball, and a position such as that shown in **(1112a)**, therefore, is outside the eyeball, although within the orbital cavity.

The position of the foreign body would be reported as follows:—

A foreign body, radiologically opaque, is present in the right eye.

The foreign body is:—

8 mm. above the central corneal axis;
4 mm. to the temporal side of the central corneal axis;
22 mm. deep to the plane tangential to the centre of the anterior surface of the cornea.

The charts show the foreign body to be external to the outer surface of the eyeball.

Foreign Bodies: Orbital Cavity

SPECTACLE METHOD (*continued*)

A clear understanding of the procedure may be gained by practising the full technique on the skull model as suggested on page 431, a small brass curtain ring fitted with fine cross-wires and an improvised "quadrant indicator" serving as an excellent substitute for the spectacle eyepiece.

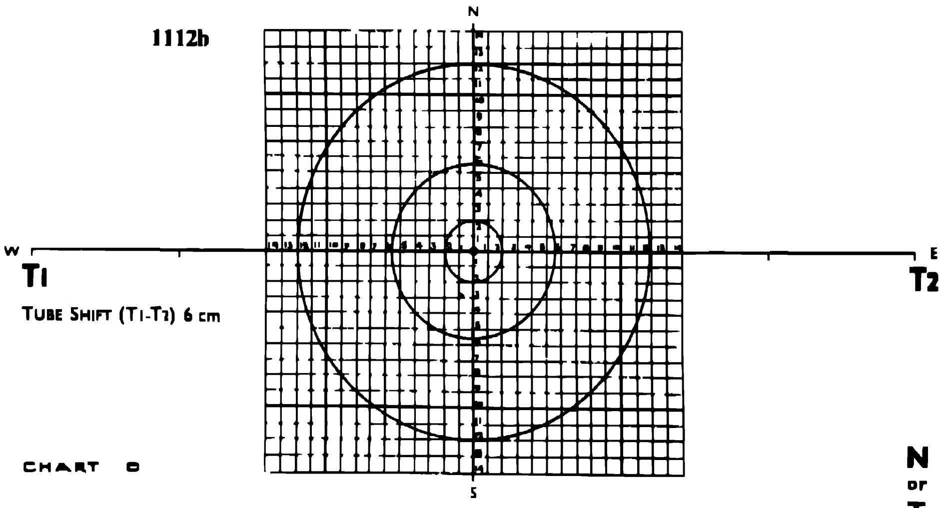
Illustration (**1112b**) shows the type of form supplied for Spectacle localisation. The actual form, however, is a little larger than the reproduction and includes also the patient's particulars.

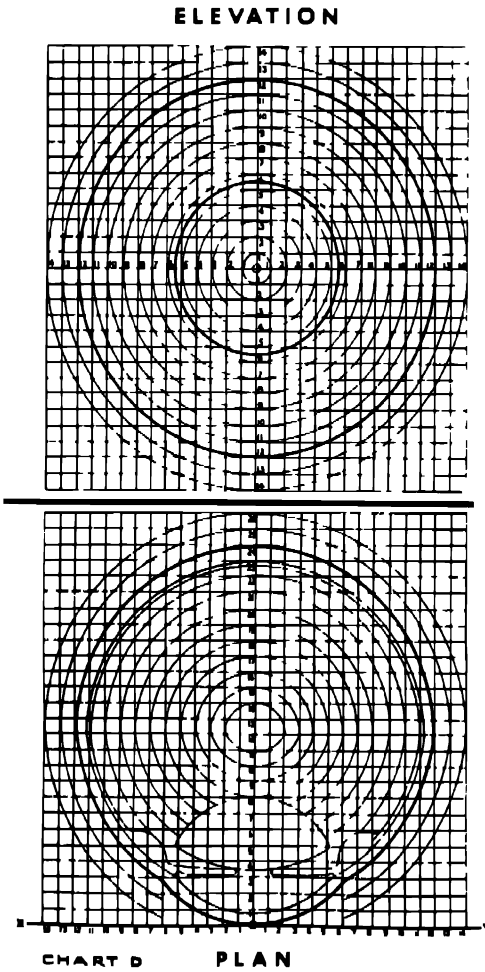
This same form may be adapted for the further development of the Point and Cross localiser, pages 442, 443.

LOCALISATION TABLE FOR AN ANODE HEIGHT OF 500–800 mm., A TUBE SHIFT OF 60 mm., AND SHADOW SHIFT OF 0·5–3 mm.

Anode	0·5	1	1·5	2	2·5	3
500 mm.	4·1	8·2	2·2	16·1	20·0	23·8
510 ,,	4·2	8·4	2·4	16·5	20·4	24·3
520 ,,	4·3	8·5	2·7	16·6	20·8	24·8
530 ,,	4·4	8·7	12·9	17·0	21·2	25·2
540 ,,	4·5	8·9	3·2	17·4	21·6	25·7
550 ,,	4·5	9·0	3·4	17·7	22·0	26·1
560 ,,	4·6	9·2	13·7	18·0	22·4	26·7
570 ,,	4·7	9·3	13·9	18·4	22·8	27·1
580 ,,	4·8	9·5	14·1	18·7	23·2	27·6
590 ,,	4·9	9·7	14·4	19·0	23·6	28·1
600 ,,	5·0	9·8	14·6	19·3	24·0	28·6
610 ,,	5·0	10·0	14·9	19·7	24·4	29·1
620 ,,	5·1	10·2	15·1	20·0	24·8	29·5
630 ,,	5·2	10·3	15·4	20·3	25·2	30·0
640 ,,	5·3	10·5	15·6	20·6	25·6	30·5
650 ,,	5·4	10·7	15·9	20·9	26·0	31·0
660 ,,	5·5	10·8	16·1	21·3	26·4	31·4
670 ,,	5·5	·0	16·3	21·6	26·8	31·9
680 ,,	5·6	1	16·6	21·9	27·2	32·4
690 ,,	5 7	·3	16·8	22·2	27·6	32·9
700 ,,	5·8	·5	17·1	22·6	28·0	33·3
710 ,,	5·9	·6	17·3	22·9	28·4	33·8
720 ,,	6·0	·8	17·5	23·2	28·8	34·3
730 ,,	6·0	·9	17·8	23·5	29·2	34·8
740 ,,	6·1	·1	18·0	23·9	29·6	35·2
750 ,,	6·2	·3	18·3	24·2	30·0	35·7
760 ,,	6·3	·5	18·5	24·5	30·4	36·2
770 ,,	6·4	·6	18·8	24·8	30·8	36·7
780 ,,	6·4	2·8	19·0	25·0	31·2	37·1
790 ,,	6·5	13·0	19·3	25·5	31·6	37·6
800 ,,	6·6	13·1	19·5	25·8	32·0	38·1

1112b





A foreign body, radiologically opaque, appears to be present in the $\frac{\text{left}}{\text{right}}$ eye.

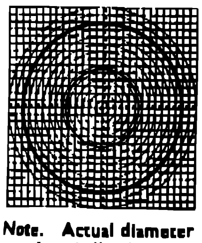
The foreign body is

mm. $\frac{\text{above}}{\text{below}}$ the central corneal axis

mm. to the $\frac{\text{nasal}}{\text{temporal}}$ side of the central corneal axis

mm. deep to the plane tangential to the centre of the anterior surface of the cornea.

The charts show the foreign body to be $\frac{\text{internal}}{\text{external}}$ to the outer surface of the eyeball



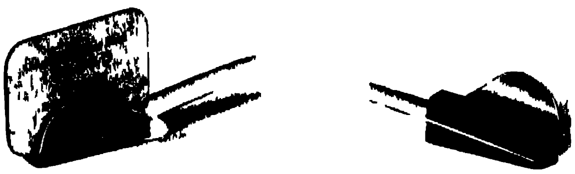
Note. Actual diameter of eyeball 24 mm.

SECTION 28

Dental

1113
(No. 1)

1114
(No. 2)



1115
(No. 3)

1116
(No. 4)

DENTAL

Although dental radiography is rapidly becoming the specialised work of the dental surgeon, a certain amount of investigation of the teeth continues to be carried out in the general X-ray department. Apparatus accordingly varies from the small, specially designed dental unit to the large, general purpose unit.

VERTICAL OR HORIZONTAL

The general preference is for vertical technique, but until comparatively recent years dental work was, in the great majority of cases, carried out with the patient lying down, and as a request for the examination of the teeth of a sick patient sometimes involves the horizontal position, the general purpose radiographer should be able to use either position. This should present no difficulty once the angulation for dental technique is understood.

The positioning given in the text embraces both the vertical, using the small dental unit, and the horizontal, using the general purpose unit.

EXPOSURE RANGE

The output required for dental technique is from 45 kilovolts to 55 kilovolts for intra-oral films, and from 55 kilovolts to 65 kilovolts for occlusal and extra-oral films. The smaller dental units usually have a set rating of 10 milliamperes at from 45 kilovolts to 55 kilovolts, with a timing device giving an exposure range of from a quarter of a second to ten seconds.

POSITIONING

Modern dental units are shock-free, this rendering possible the use of the special dental cone in contact with the skin, an anode-film distance of from 7 inches to 9 inches being applied. These units move freely, and the patient may therefore remain seated in the dental chair, or in a chair fitted with a modified head support, while the tube is moved round the head to the various positions. In using the general purpose unit, however, the patient usually lies down, and an anode-film distance of from 20 inches to 24 inches is applied, a small localising cone being used.

FILM HOLDERS

In positioning the intra-oral films various types of dental film-holders may be used. A useful type shown includes four separate holders, one each for the upper (No. 1) **(1113)** and lower (No. 2) **(1114)** incisor regions, one for the left upper and right lower jaws (No. 3) **(1115)** and one for the right upper and left lower jaws (No. 4) **(1116)**. Each holder is shown both with and without the film in position. The holders are easily handled and sterilised.

Although many workers allow the patient to hold the films in position, the method, although it is here shown in illustrating the use of the general purpose unit, obviously cannot be satisfactory in every case.

FILMS

Dental films are made in two types, Special Standard and Contrast, these being fast and slow, respectively. They may be used according to the technique preferred, and are packed singly or in pairs, use of the latter pack enabling one complete set of films to be retained for record purposes. The film pack contains a lead foil between film and label to absorb secondary X-radiation, definition being thus enhanced.

Intra-oral films are available in two sizes, the standard size, $1\frac{5}{8}$ inches by $1\frac{1}{4}$ inches, and the sub-standard, $1\frac{1}{4}$ inches by 1 inch. The smaller of these is very useful when examining the incisor and canine regions in a narrow and shallow mouth, and also for children.

A larger film, termed "occlusal," in size 3 inches by $2\frac{1}{4}$ inches, is so named from its position—in the occlusal plane between the jaws—during exposure. Small cassettes and intensifying screens are available for use with this film, which is obtainable ready packed for use without screens. A smaller occlusal film, in size $2\frac{1}{4}$ inches by $1\frac{1}{2}$ inches, is used in the same position for small localised areas.

Other sizes of film used for investigation of mouth and jaw are the whole plate and half plate, which are employed for extra-oral work, these being the sizes used in the examples given also in Section 10.

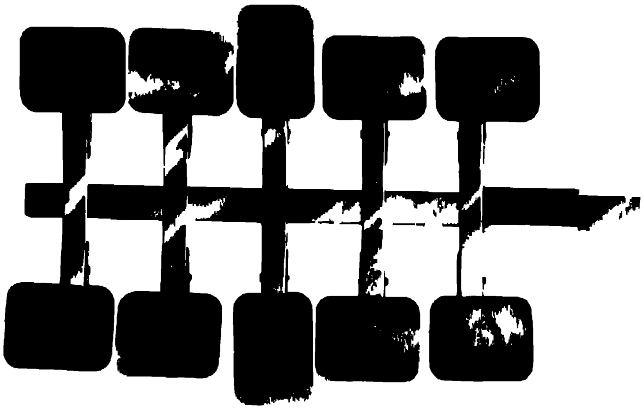
DEVELOPING HANGERS

Processing may be carried out in the general X-ray developing tanks, while the specialist worker will use the small dental processing unit.

The developing hanger makes possible the processing of a complete set of films in the position in which they will be finally mounted, the patient's identification number or name being noted on the small celluloid tab fitted for the purpose **(1117)**.

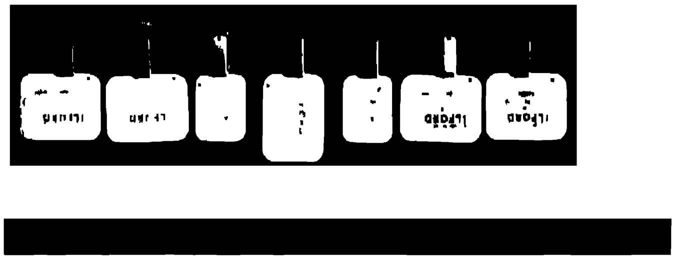
IDENTIFICATION

Individual films should on no account be pencil marked before being processed. Identification of position is facilitated by the provision on each film of a small indentation corresponding in position with a black star on the outer wrapping of the film pack. The pack is placed in the mouth with the *unstarred* side, and therefore with the slightly *raised* mark on the enclosed film, *toward* the teeth to be examined, the mark on the wrapping being positioned toward the crown of the teeth to avoid the otherwise possible obscuring of the more important apices **(1118)**.



1117

Films should be mounted to appear as the mouth is seen by the surgeon from the labial aspect, that is, with the patient's right to the left of the mount. It is appreciated, however, that certain workers prefer to view dental films as the teeth would be seen from the lingual aspect, in which case the mounting of the films would be reversed,



1118

the right and left sides of the mouth being placed to the right and left sides of the dental mount, respectively. In handling films care should be taken to ensure that finger and thumb impressions do not show, and workers who find difficulty in avoiding this marking of films should handle them only between tissue paper or should, as recommended, use the celluloid dental film holders supplied for the purpose.

NUMBER AND POSITION OF TEETH

The human being develops two sets of teeth. The temporary, milk or deciduous, set, numbering twenty, appears between the ages of six months and two years (1120a), giving place to the permanent teeth, thirty-two in number (1121), which erupt from the sixth year onward, the last four molars, or wisdom teeth, appearing normally during the eighteenth year. These wisdom teeth may not erupt, however, until as late as the twenty-sixth year, and may occasionally remain embedded in the jaw, for which reason, even if no wisdom tooth is visible in the mouth, this area should always be included in a complete set of films (1121).

Extra-oral films of a child aged eight years are shown in (1118a).

1118a

DENTAL REQUEST FORMULA

Requests for dental X-ray examination are made in accordance with the dental formula (1118b, 1118c), the number of teeth to be examined being specified, or similar indication may be given in the case of the toothless, or edentulous, subject to be examined for the location of buried roots or abnormal condition of the alveolar margin. The examination of children may be required when teeth of both dentitions are present.

Milk teeth are often referred to by serial *letters* from "a" to "e" on passing from central incisor laterally to second milk molar (1118b, 1120a).

e d c b a	a b c d e
e d c b a	a b c d e

1]

Permanent teeth are often referred to by serial *numbers* from "1" to "8" on passing laterally from central incisor to third molar (1118c, 1118d, 1121).

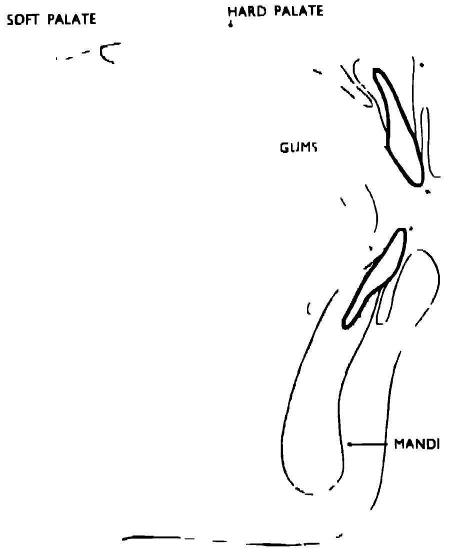
R.	8 7 6 5 4 3 2 1	1 2 3 4 5 6 7 8	L.
	8 7 6 5 4 3 2	1 2 3 4 5 6 7 8	

1118c

	456		
876			78

1118d

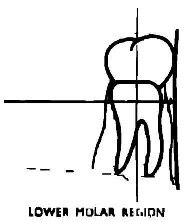
Each tooth, consisting, briefly, of crown, neck and root or roots—each root terminating in an apex—is set in the jaw with, normally, only the crown visible, the remainder of the structure being embedded in the alveolar process of the jaw. The alveolar process is covered with the soft structure forming the gum (1119).



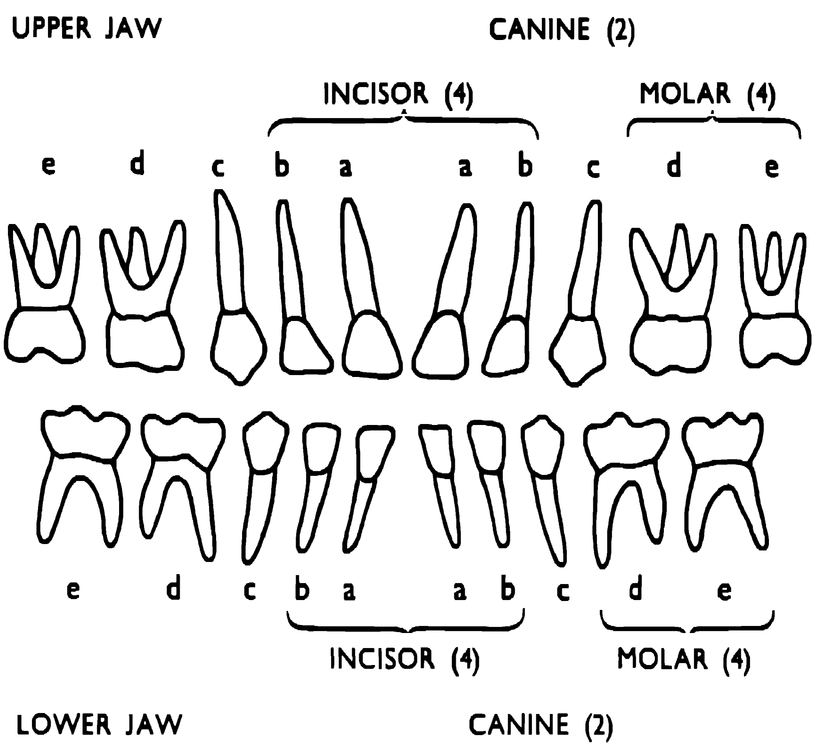
VERTICAL SECTION NEAR MIDLINE OF JAWS

1119

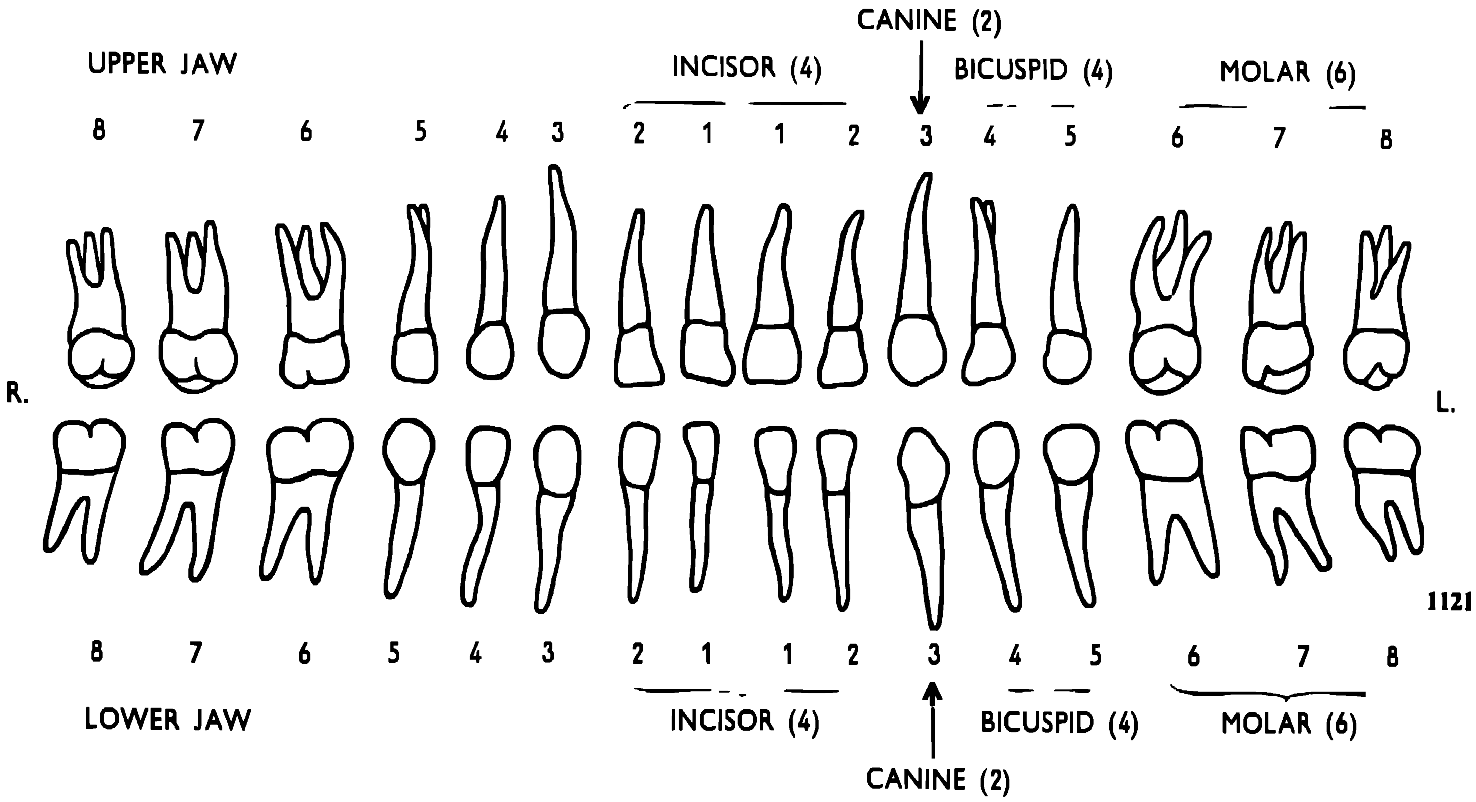
A film, therefore, placed in the mouth and in contact with the crown of a tooth and with the gum is somewhat removed from the root of the tooth, the angle between tooth and film varying from patient to patient and according to the region of the mouth: it is greatest in the upper incisor area (1119), while in the lower molar region it is negligible, it being possible, in fact, to work here with the film parallel to the tooth (1120). Reference should be made to page 463.



1120


UPPER JAW
CANINE (2)
INCISOR (4)
MOLAR (4)
e d c b a a b c d e
e d c b a a b c d e
INCISOR (4)
MOLAR (4)
LOWER JAW
CANINE (2)

1120a


CANINE (2)
UPPER JAW
INCISOR (4)
BICUSPID (4)
MOLAR (6)
8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8
R.
L.
8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8
LOWER JAW
INCISOR (4)
BICUSPID (4)
MOLAR (6)
CANINE (2)

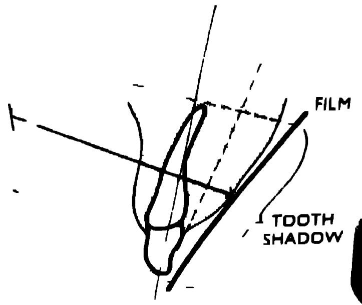
1121

CORRECT PROJECTION

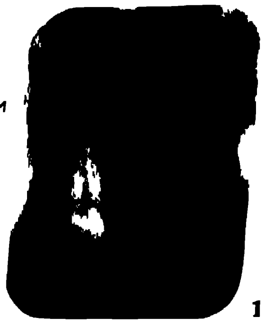
This should be fully appreciated before dental radiography is embarked upon, as such conditions, when tube centring is at fault, are ideal for producing what is described as *true* distortion, this being considerably emphasised when a short anode-film distance is employed, as is the case when using the small dental unit at a nine inches distance or less.

The aim in projection should be to direct the beam at right angles to the line bisecting the angle between tooth and film, as this gives the nearest approach to the normal length shadow of the tooth (**1122**). Projection toward the crown gives rise to foreshortening (**1123**), that toward the apex resulting in elongation of the tooth shadow (**1124**), and while some degree of foreshortening is permissible, elongation is to be avoided. The central ray should be directed toward the apical half section of the tooth. The diagrams show varying tube angulation applied to the incisor region, and the accompanying films show the result of such tube angulation (**1122, 1123, 1124**).

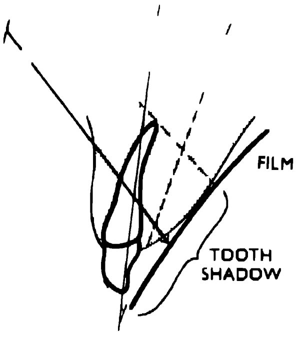
Lateral distortion—which varies the breadth and, therefore, allows overlapping of the tooth shadows—is also to be guarded against (**1125**). While it is sometimes unavoidable, owing to the manner of growth of the teeth or to the shape of the mouth, careful centring and the taking of additional films will do much to minimise its effects (**1126**). The shape of the mouth and direction of the teeth should be noted before commencing the examination: the broad mouth showing a good, regular, anterior curve is easily negotiated, but the very narrow mouth can sometimes only be demonstrated satisfactorily by using small films and by centring for each of the front teeth in turn. A shallow palate also requires greater tube angulation than that necessary for a high palate.



CENTRING CORRECT

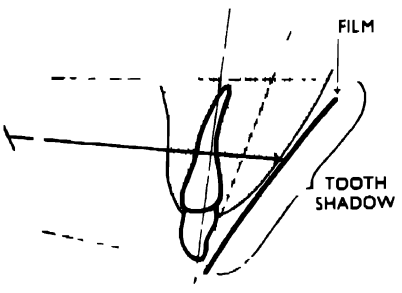


1122

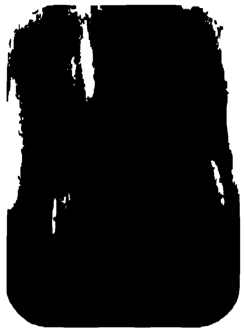


FORESHORTENING

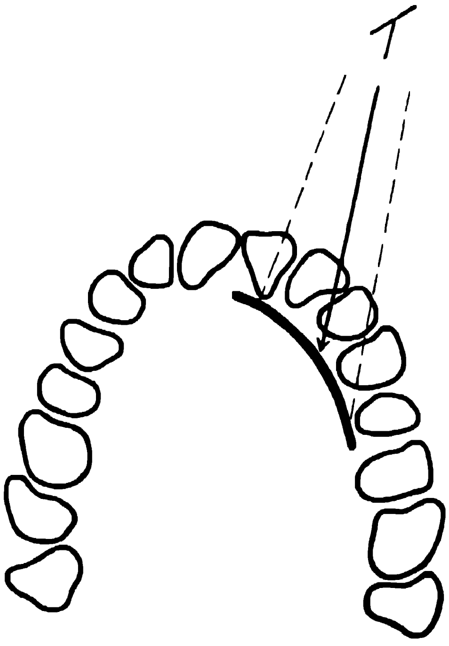
1123



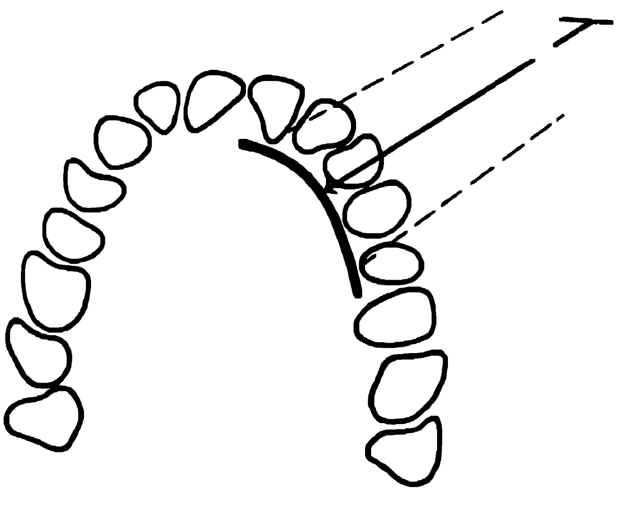
ELONGATION



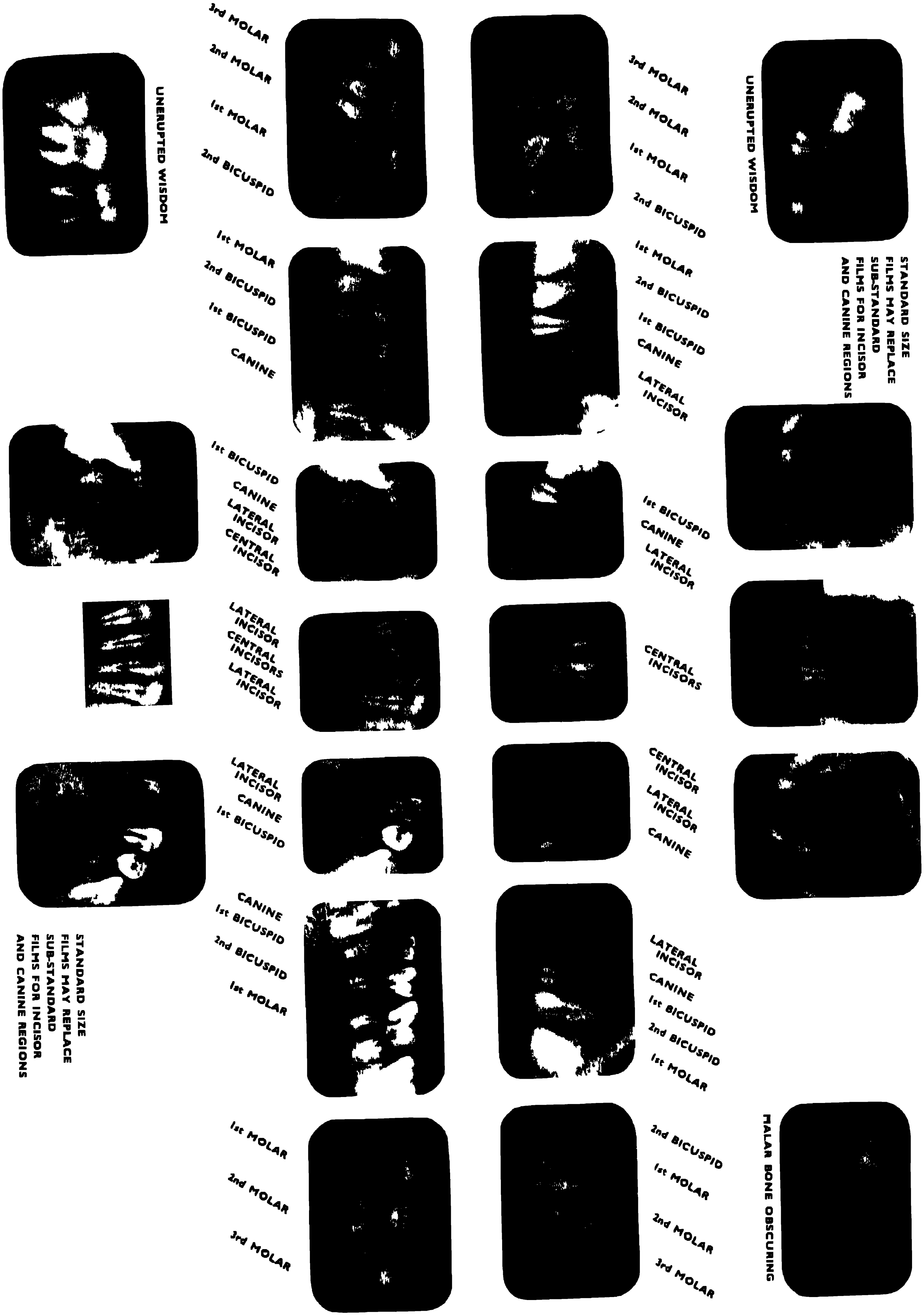
1124



LATERAL DISTORTION 1125



CENTRING CORRECT 1126


UNERUPTED WISDOM
3rd MOLAR
2nd MOLAR
1st MOLAR
2nd BICUSPID
3rd MOLAR
2nd MOLAR
1st MOLAR
2nd BICUSPID
UNERUPTED WISDOM
STANDARD SIZE FILMS MAY REPLACE SUB-STANDARD FILMS FOR INCISOR AND CANINE REGIONS
1st MOLAR
2nd BICUSPID
1st BICUSPID
CANINE
1st MOLAR
2nd BICUSPID
1st BICUSPID
CANINE
LATERAL INCISOR
1st BICUSPID
CANINE
LATERAL INCISOR
CENTRAL INCISOR
1st BICUSPID
CANINE
LATERAL INCISOR
LATERAL INCISOR
CENTRAL INCISORS
LATERAL INCISOR
CENTRAL INCISORS
LATERAL INCISOR
CANINE
1st BICUSPID
CENTRAL INCISOR
LATERAL INCISOR
CANINE
CANINE
1st BICUSPID
2nd BICUSPID
1st MOLAR
LATERAL INCISOR
CANINE
1st BICUSPID
2nd BICUSPID
1st MOLAR
STANDARD SIZE FILMS MAY REPLACE SUB-STANDARD FILMS FOR INCISOR AND CANINE REGIONS
1st MOLAR
2nd MOLAR
3rd MOLAR
2nd BICUSPID
1st MOLAR
2nd MOLAR
3rd MOLAR
MALAR BONE OBSCURING

1127

EXAMINING THE MOUTH

Before taking dental radiographs it is essential to examine the mouth and to make careful note of the teeth present and of their position in the jaw. It is important to be able to identify the teeth in the mouth, especially in cases in which extractions have been made. The chisel-shaped incisors are easily recognised, but if there are only three remaining care must be exercised in determining the mid-line. The canine crown is conical and pointed; and the pre-molars, which are inclined to be oblong in shape, present two small eminences separated by a groove. The molar crowns, which tend to be square, have four or five small eminences divided by a cross-shaped depression.

Mastication and repair fillings may so modify the appearance of the crowns that identification of remaining teeth is difficult: identification should, however, always be attempted.

TECHNIQUE

To show a complete set of teeth the size and number of films used depend upon the shape of the mouth. In some cases ten films may suffice; in others fourteen or even more may be necessary. Centring is therefore shown in this section for both a fourteen-film and a ten-film series. **(1127, 1129)**

The illustrations include tracing diagrams taken from occlusal films of upper and lower jaws, with correct film positions embodied. The radiographs show right and left sides where applicable.

For vertical technique the patient is placed, for both upper and lower jaw examinations, with the head supported and immobilised with its medial plane vertical and the occlusal plane horizontal. It should be possible to maintain this position throughout the examination: in the *horizontal* position, however, a certain movement of head and tube is necessary.

Illustration **(1127)** shows a fourteen-film series, with alternative film size for upper and lower canine and incisor regions. A ten-film series for the edentulous mouth is shown in **(1129)**.

VIEWING

In a complete series the films should be so arranged that each tooth appears free from all distortion in at least one film **(1127)**; and on completing such a series of exposures the films should be developed and checked, if possible, before the patient leaves, in order that any fault may be rectified or any unusual variation from the normal be further investigated.

EXPOSURE FACTORS FOR SPECIAL STANDARD AND CONTRAST DENTAL FILM

Using a dental unit having a set output of approximately 55 kilovolts and 8 milliamperes, at an anode-film distance of 9 inches, the exposure times, using Ilford X-ray Developer under standard conditions, are as follows:—

Region	Ilford Dental Films: Special Standard No. 5 (pairs) No. 4 (single)	Ilford Dental Films: Contrast No. 15 (pairs) No. 14 (single)
Upper Incisors ..	sec.	4 secs.
Upper Canines	$\frac{3}{4}$ sec.	$3\frac{1}{2}$ secs.
Upper Bicuspids ..	$\frac{3}{4}$ sec.	$3\frac{1}{2}$ secs.
Upper Molar	1 sec.	$5\frac{1}{2}$ secs.
Lower Incisors	$\frac{1}{2}$ sec.	$2\frac{1}{2}$ secs.
Lower Canines	$\frac{3}{4}$ sec.	$3\frac{1}{2}$ secs.
Lower Bicuspids ..	$\frac{3}{4}$ sec.	$3\frac{1}{2}$ secs.
Lower Molar	$\frac{3}{4}$ sec.	4 secs.
Lower Occlusal without Screens. Number 3 films	$1\frac{1}{2}$ secs.	at 10 inches distance
Upper Occlusal with number 3a films and Ilford Tungstate Screens	$1\frac{1}{2}$ secs.	at 16 inches distance

These exposure times apply to an adult subject of average physique. For the general purpose unit the anode-film distance should be doubled and the milliampere seconds adjusted accordingly.

Edentulous Subjects

It is an advantage when dealing with the toothless subject to allow an existing denture to be retained in the one jaw while the other jaw is being examined, the patient thus being able the more easily to maintain the film holder in position. To prevent the alveolar margin from being obscured a dental roll is placed between the gums and the bite block. Tube angulation is always increased and the exposure time considerably reduced, the slower contrast film being the more suitable in these cases. Care should be taken to cover the whole area involved, using ten films for a complete set; and in any difficulty experienced in localising the position of a buried root the taking of a general extra-oral or occlusal film will be found to be of assistance. Reference should be made also to occlusal technique and localisation described on pages 464 and 465.

Illustration **(1129)** shows a ten-film series taken of an edentulous subject.

The two extra-oral films **(1128)** were taken of the same subject, applying the technique described and illustrated on page 466.

The technique for each region of the mouth is given in the following pages.

UPP AW

29

.OWER AW

28

1130

1131

1132

Dental: Upper Jaw

Incisors

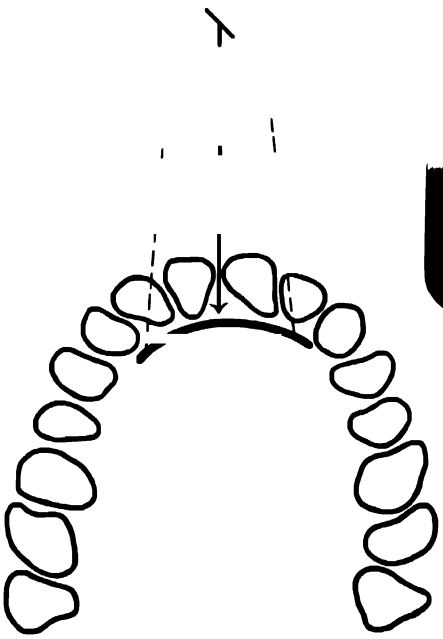
A standard sized film is usually necessary for the incisor region, the tube being angled with the axial ray directed obliquely through the tip of the nose and final adjustment made after the film has been placed in position. After being gently moulded to the shape of the mouth the film is fitted into a number 1 film holder, which is placed in position in the opened mouth and the film pressed against the incisor region, with the crowns of the teeth in contact with the bite block **(1130)**; the lower jaw is then closed on to the holder bite, the film holder being thus maintained in position with the film pressed to the gum **(1131)**. Final centring of the tube, the angle of which to the occlusal plane may vary from 50 degrees to 60 degrees, according to the set of the teeth in the jaw, brings the tube cone (when shock free) into contact with the nose, the tube being then at right angles to the chord of the curve of the teeth **(1133)**.

(1131, 1133, 1133a)

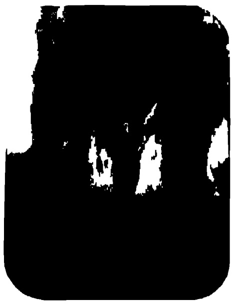
For the horizontal position the head is raised on sand-bags and adjusted with the occlusal plane approximately vertical, and the tube, at an anode-film distance of 20 inches, and fitted with a small localising cone, is directed toward the tip of the nose and at an angle of from 50 degrees to 60 degrees to the occlusal plane **(1132, 1133, 1133a)**.

In the illustration **(1132)** the patient is holding the film in position with the left thumb.

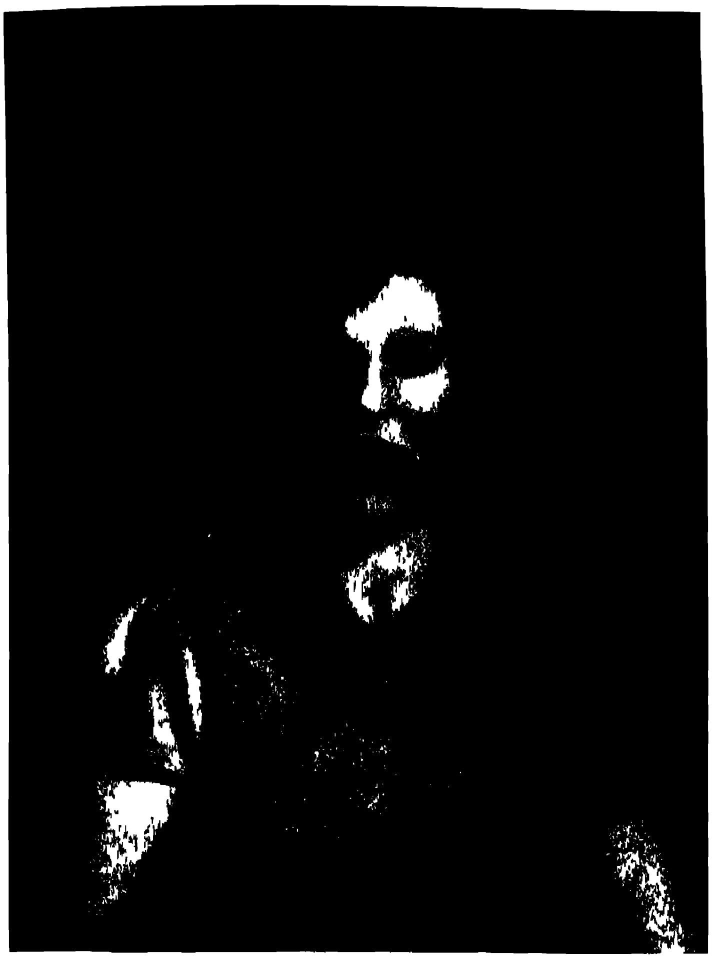
In the broad mouth the large film placed lengthways or broadways will show the four incisors clearly. In the narrow mouth, however, the film placed vertically will



1133



113



1134

1135

show the centrals satisfactorily, but the lateral incisors may show lateral distortion.

An edentulous mouth requires greater tube angulation, with the insertion of a dental roll between gum and holder bite.

Lateral Incisors and Canines

NARROW MOUTH

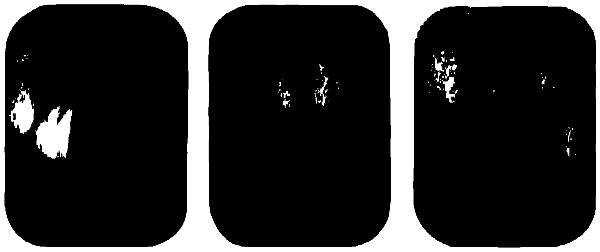
The narrow mouth necessitates the taking of additional small films of this region. The tube is moved to the right and the left of the nose in turn, and the tube's angle to the occlusal plane is maintained at 60 degrees. The film is placed vertically in a number 3 or number 4 holder and introduced into the mouth with its medial edge in the mid-line; the mouth is closed on to the holder bite, and the tube finally adjusted in position with the cone resting against the face.

(1134, 1135, 1136, 1136a)

The lateral incisor and canine teeth are thus shown **(1136)**. Should definition and separation not be adequate, further exposures should be made with slightly different lateral tube angulation.

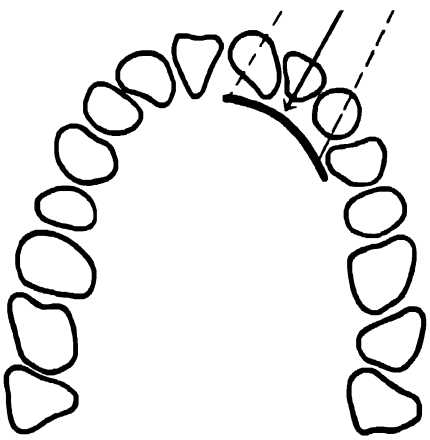
This view is required for the fourteen-film technique.

(1127)



1136

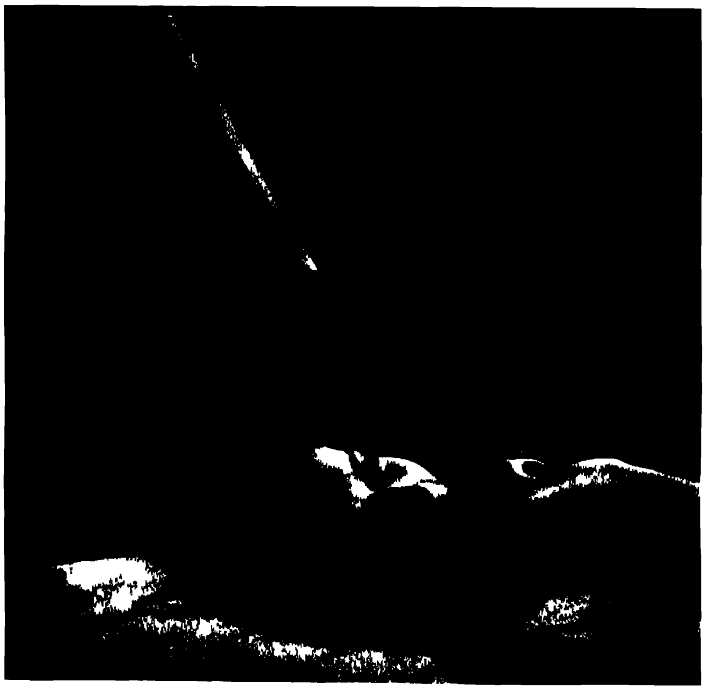
R CENTRAL L



1136a


1137


1138


1139

Dental: Upper Jaw

Lateral Incisors, Canine and Bicuspids

BROAD MOUTH

For the broad mouth, which allows the lateral incisors to be shown in the central film (1133a), a second large film may be used horizontally to include lateral incisor, canine and two bicuspids.

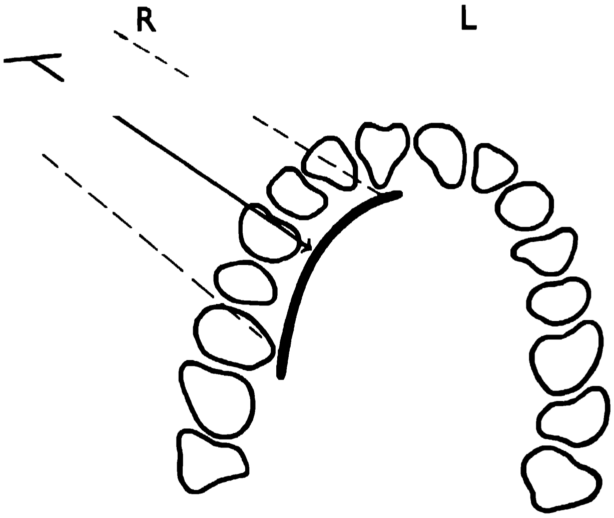
A number 3 holder for the left side or a number 4 for the right side is placed in position with the anterior margin of the film between the central incisors. The tube is centred anteriorly to the malar bone and angled at approximately 45 degrees to the occlusal plane and at right angles to the chord of the curve of the teeth.

(1137, 1138, 1140, 1141)

In applying horizontal technique the head is turned until this region is horizontal, tube angulation being adjusted accordingly. The index finger is used by the patient to hold the film in position (**1139, 1140, 1141**).

The edentulous mouth is treated similarly, save that a dental roll is placed between gum and bite block and that increased tube angulation may be necessary.


114



1141

Dental: Upper Jaw

Molar

Here careful positioning and centring are necessary to avoid overshadowing by the malar bone, and, as the back of the mouth is usually very sensitive, special care should be taken in ensuring that the film is placed sufficiently to the back of the mouth to include the third molar or wisdom tooth, which may be higher in the gum than is perhaps anticipated. The tube is moved round the face and centred below the malar bone and slightly forward, to be at right angles to the general transverse plane of the film, and the tube angulation is still further reduced by 10 degrees, the angle now employed being approximately 20 degrees less than that for the central incisor region (**1142, 1143, 1145, 1146**).

Number 4 holder is used for the right side and the film so placed as to include the second bicuspid and the three molars. When the malar bone is shown to obscure the roots (**1145R**) a small dental roll is placed between holder and film so that the film becomes generally parallel to the teeth, the tube being then centred at right angles to the film.

For horizontal positioning the head is turned to allow the molar region to be horizontal and the tube angle is adjusted to between 35 degrees and 40 degrees, as in the case of vertical work. The film is held in position by the patient's index finger (**1144, 1145, 1146**).

The edentulous mouth should be carefully negotiated, as owing to the absence of the teeth the film may easily be placed uncomfortably far back toward the throat, and a large dental roll should be placed between gum and bite block.

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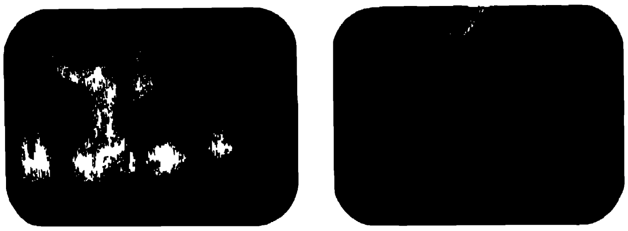
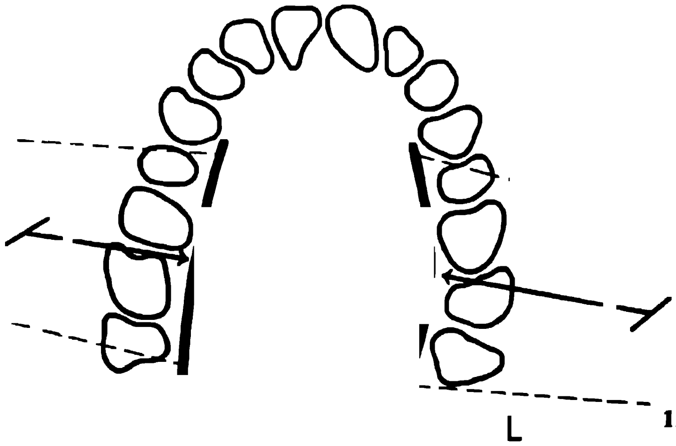


R MALAR BONE OBSCURING ROOTS

L

1145



1146

Dental

Lower Jaw

Tube angulation for the lower jaw is usually considerably less than that required for the upper jaw, although the lower centrals may be so placed as to require considerable angulation. The bite surface of the lower teeth should be horizontal for vertical technique, and vertical for horizontal work, and as the lower jaw is relatively shallow it is not always possible to place the large films lengthwise to the long axis of the teeth when using the dental holder.

Incisors

In the narrow mouth it will be necessary to use the *small* dental films, placed lengthwise to the long axis of the teeth, using three films—one for the central incisor and one each for right and left lateral incisor and canine.

The broad mouth will, however, permit the use of the *large* dental film placed horizontally, which will include the four incisors.

The film, in a number 2 holder, is placed in position in the lower jaw **(1147)**, which is then raised to bring the holder bite into contact with the upper teeth **(1148)**, the tube being adjusted at an angle varying from 15 degrees to 30 degrees to the occlusal plane, and with the cone frequently making contact with the angle of the chin **(1148, 1150, 1151)**.

For horizontal positioning the neck is allowed to extend over a sandbag until the bite surface of the lower teeth is

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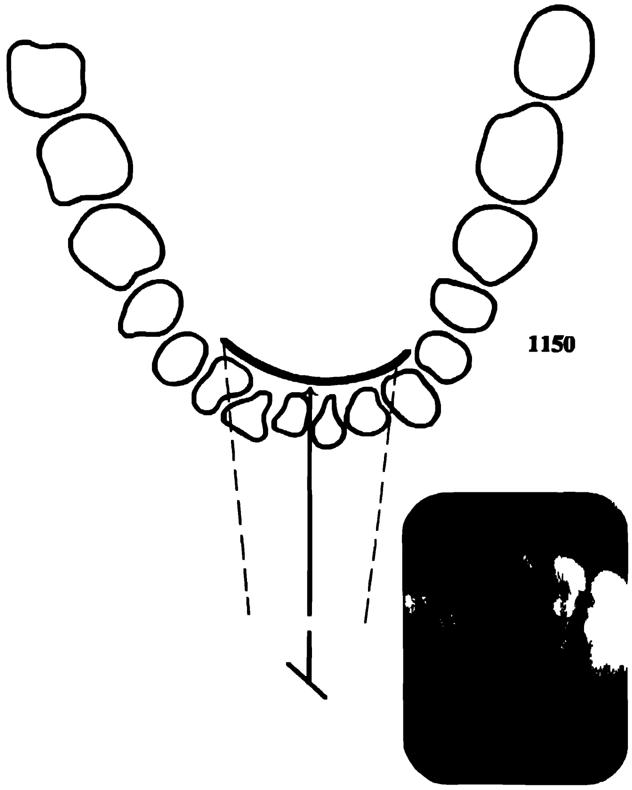


1150

1151

vertical; the film is held in position by the patient's index finger and the tube angled at from 15 degrees to 30 degrees, through the lower jaw, and in the mid-line **(1149, 1150, 1151)**

The small film used for the narrow mouth will show the two centrals without distortion, all four incisors being similarly demonstrated in the large film used in the broad mouth. **(1148, 1150, 1151)**

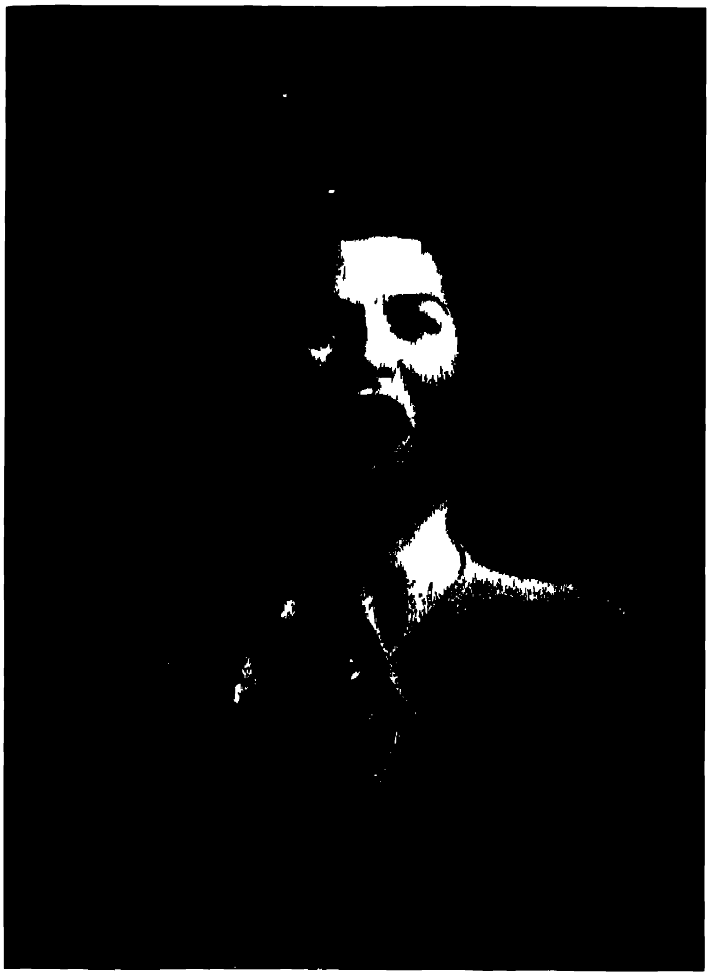
Lateral Incisors and Canines

As is the case in the upper jaw with narrow palate, so additional films are necessary also for the lower jaw, numbers 3 and 4 holders being used, respectively, for right and left sides.

The tube is moved to centre directly between lateral incisors and canine teeth, with the same angulation as for the central film. The films are placed with the anterior edges between the central incisors, the lateral incisors and canines being thus satisfactorily shown. **(1152, 1153, 1154, 1155)**

Additional films taken with variation in the lateral angulation of the tube will allow badly placed and overlapping teeth to be demonstrated satisfactorily.

This view is required for the fourteen-film technique **(1127)**.



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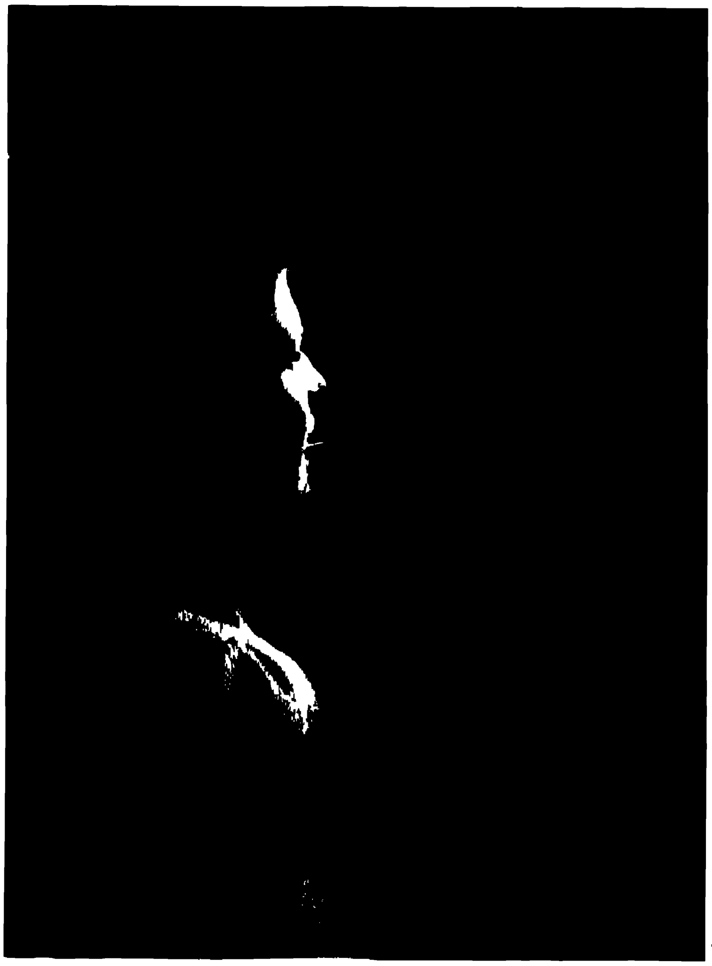

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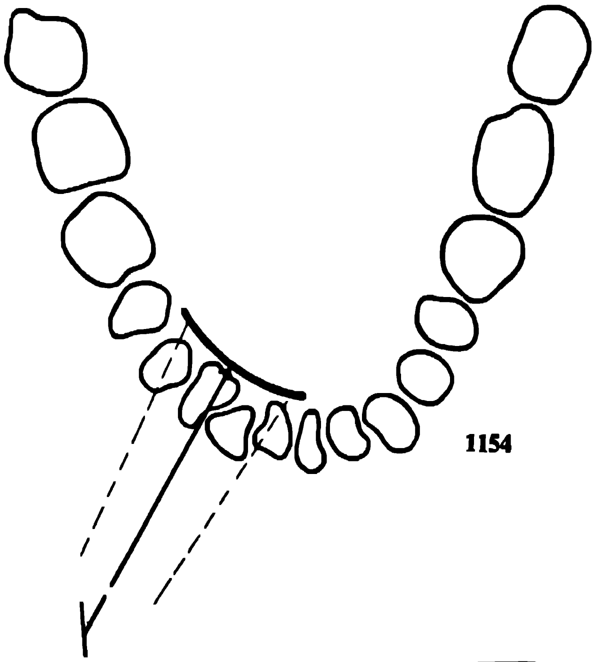


1154

1155

Dental: Lower Jaw

Canine and Bicuspids

The broad mouth will allow a large dental film to be exposed horizontally, using numbers 3 and 4 holders, respectively, for right and left sides.

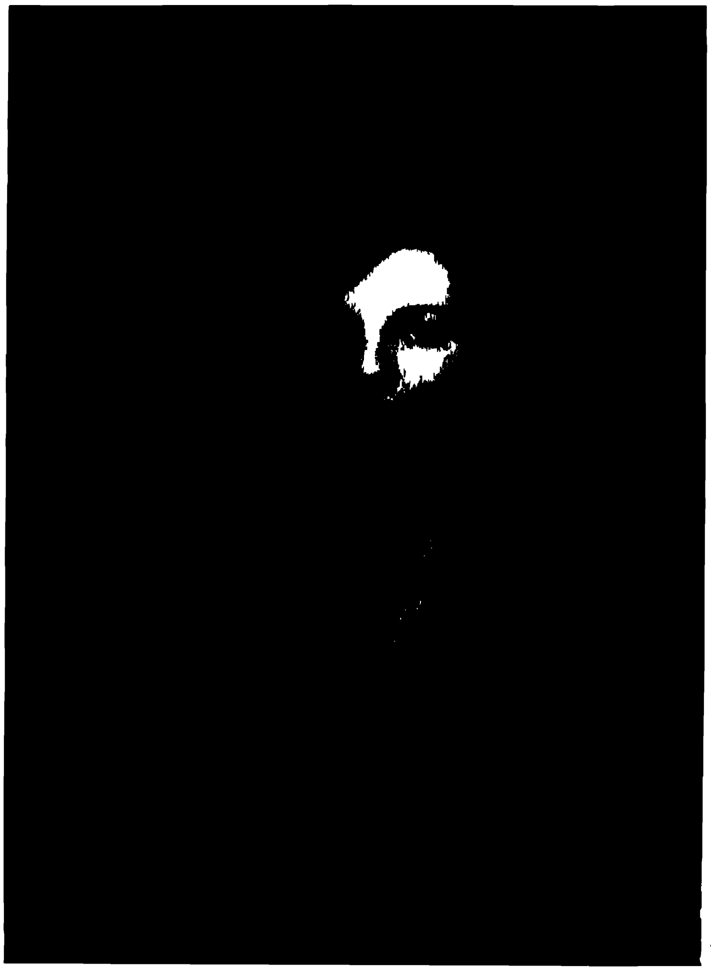
The film is placed with its anterior edge level with the central incisors, and tube angulation is reduced to within 10 degrees of the horizontal, the direction being maintained at right angles to the chord of the curve of the teeth.

An undistorted view of canine and bicuspids is obtained, and the first molar may also be included **(1159R)**. For the fourteen-film series, however, the film may be placed to show particularly the bicuspids and first molar **(1159L)**.

(1156, 1158, 1159)

For horizontal positioning the head is turned to allow the general transverse plane of these teeth to become horizontal, the tube angle being further reduced to 10 degrees from the vertical. The film is held in position by the index finger.

(1157, 1158, 1159)



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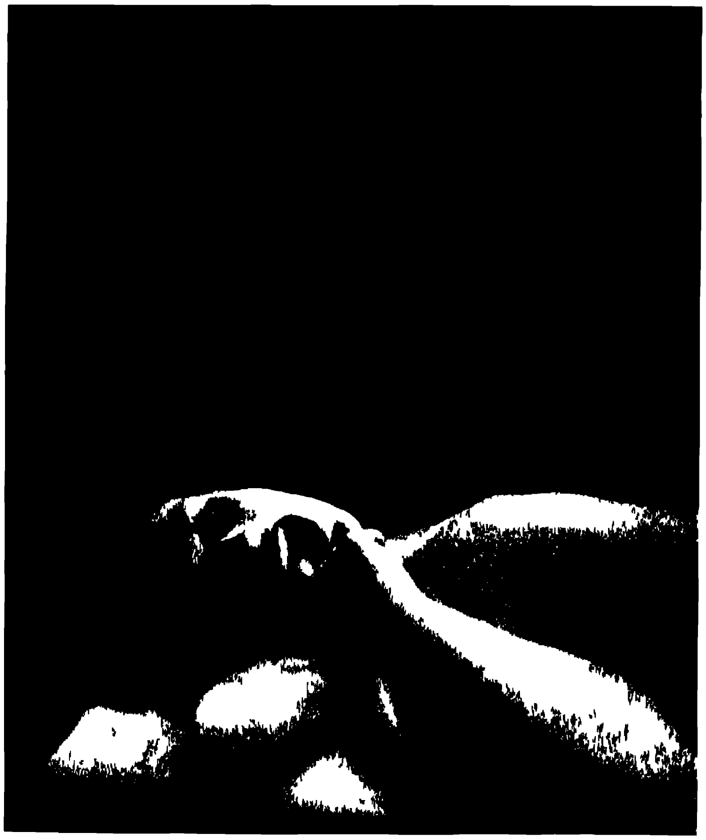

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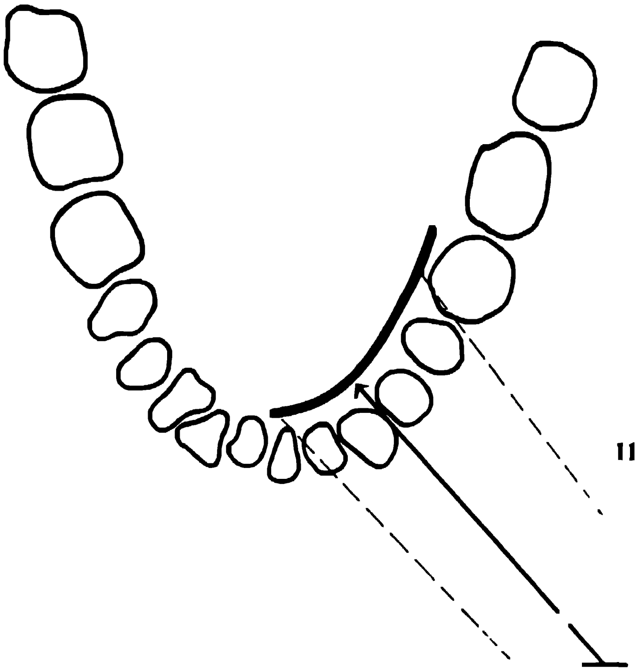

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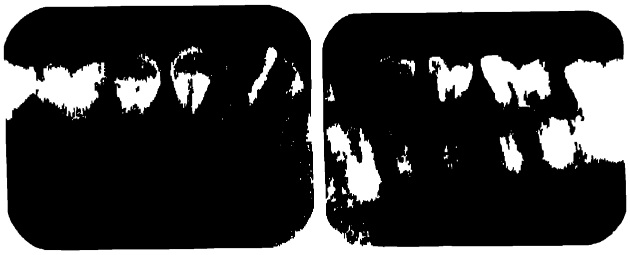

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1161

Dental: Lower Jaw

Molar

When examining this region there is a tendency to allow the film to slip too low in the jaw and thereby to omit the crowns.

The films are placed almost parallel to the teeth, so that not more than 5 degrees tube angulation, if any, is required.

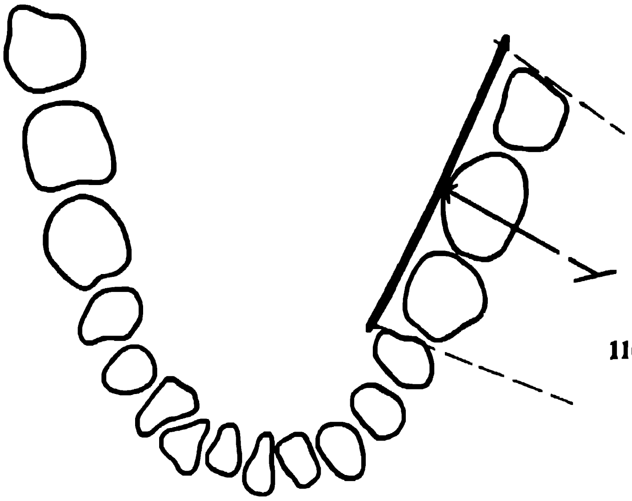
Care should be taken to see that the film is far enough back in the mouth to include the third molar, or wisdom tooth: this may present difficulty, however, and it is sometimes necessary to take an extra-oral film of the molar region.

(1160, 1162, 1162a)

For couch technique the head is turned to bring the molar region to the horizontal, the tube angle is reduced to 5 degrees, or less, and the film, placed with the upper border above the level of the molar crowns, is held in position by the index finger.

(1161, 1162, 1162a)

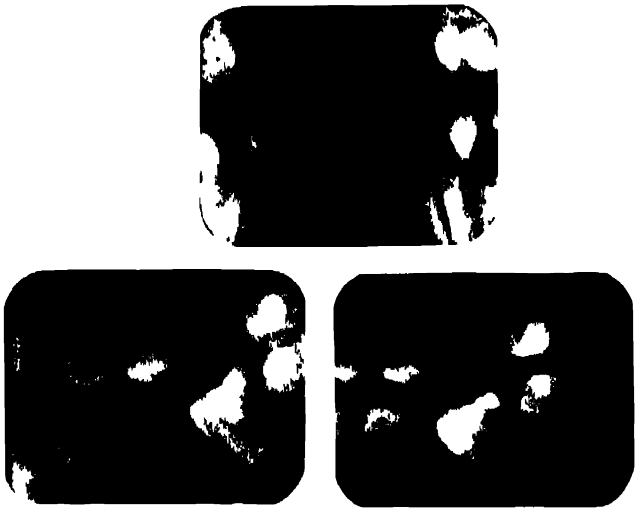
The three molars should be shown satisfactorily. It is occasionally necessary to vary the tube direction as between right and left sides, as shown in the diagram **(1146)** of the upper jaw, on page 459, and also to angle the tube *downward* toward the tooth when, as may sometimes happen, a wisdom tooth and, perhaps, the adjacent second molar are set obliquely in the jaw with the crowns nearer to the film than are the roots.



1162

1162a

1163



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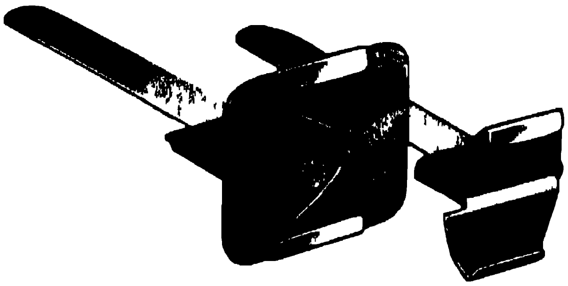


1164a

1164b

Dental: Crowns

Additional films are sometimes required to show the crowns; also an occlusal, either local or general, to show a plan of the teeth, and an extra-oral for general views of the jaw, or when the mouth is injured or too tender to permit the insertion of intra-oral films.

Crowns

It is sometimes necessary to take special films to investigate the crowns of the teeth for interstitial caries. When necessity arises, an ordinary standard dental film may be adapted by hinging centrally thereto a loop of adhesive tape on which the teeth may close, the film being firmly held in a vertical position on the lingual aspect of the upper and lower crowns, when, with the tube centred in the occlusal plane itself and at right angles to the film, the crowns of both upper and lower teeth are shown. Five films are required to complete this examination, three of which are shown **(1163, 1164)**.

Caries Dental Film Holders **(1164a)** allow both standard and small dental films to be supported in the correct position in the mouth. The film is fitted into two grooves in the aluminium holder, which is placed in the mouth with the horizontal arm projecting at right angles to the teeth, thus indicating the direction of the X-ray beam for tube centring. A small rubber-covered bite block allows the film holder to be held firmly in position between the teeth. Additional rubber bands are supplied with each set of film holders.

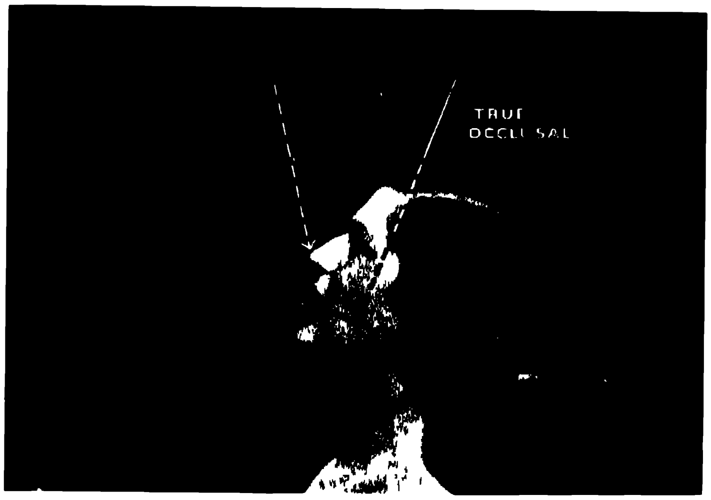
Occlusal

Should the presence of a cyst or other abnormality not be fully shown on the dental film, an extra-oral or an intra-oral occlusal film should be taken. To disclose the exact position of unerupted teeth, it is essential to take a *true* occlusal view.

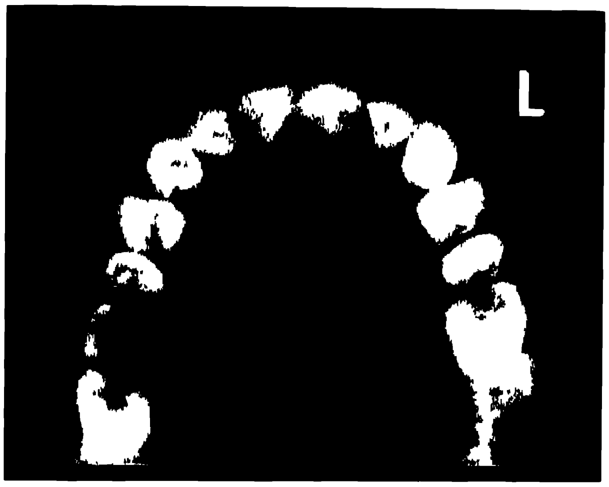
The application of the occlusal film is shown under *Maxillæ*, on pages 193, 194, and 195, for the upper occlusal views, and under *Mandible*, on page 209, for the lower occlusal and, therefore, only a brief outline of the technique employed is included in this section. The small occlusal films **(1164b)** are of a convenient size for small localised areas where there is difficulty in applying the large films **(1165a, 1166a)**.

UPPER JAW

The occlusal cassette, in a cellophane envelope, is placed transversely between the jaws, where it is held lightly in position by the upper and lower teeth.



1165



1165a

1166

1166a

Dental: Occlusal

UPPER JAW *(continued)*

CENTRE through the vertex of the skull at right angles to the occlusal cassette **(1165, 1165a)**.

The resulting radiograph **(1165a)** shows a plan of the upper teeth, this being a *true* occlusal view which is particularly suitable for showing unerupted incisors and canines. It should be noted that intensifying screens are essential for this projection.

Radiograph **(548)** on page 194 shows the result of centring through the nose at an angle of 60 degrees to the film as indicated by the broken line in **(1165)**. For this view, however, double-wrapped films are employed, intensifying screens being unnecessary.

LOWER JAW

The double-wrapped occlusal film is placed between the jaws, but with the exposure surface toward the lower teeth. The head is tilted well back to enable the dental unit to be placed in the correct position for centring.

CENTRE from below the jaw at right angles to the occlusal film **(1166, 1166a)**.

The result of this positioning and centring is shown in **(1166a)**, a *true* occlusal view which is of particular value for the purpose of disclosing the relationship of an unerupted wisdom tooth to the alveolar margin of the jaw.

Radiograph **(588)** on page 209 was obtained by centring through the chin at an angle of 45 degrees to the film as indicated by the broken line in **(1166)**. It should be noted that as in the case of dental films, the star on the film pack indicates the position of an indentation on the film itself and by routine direction placing of the film in the mouth, for example, the star toward the incisor region, the right and left sides of the radiograph are readily identified. This applies also to loading the film and to the positioning of the occlusal cassette in the mouth.

Localisation

To enable the *relative* position of a root fragment to be appreciated, particularly in an edentulous mouth, it is necessary to place an opaque marker, such as a small piece of wire, in contact with the gum before exposing the films. It is essential, however, to be able to replace the marker in the original exposure position when the radiographs are examined at the time of the extraction. The principle of parallax, previously discussed on page 435, may be applied to ascertain the relative positions of unerupted and erupted teeth, two exposures, from slightly different angles, being made on the one film to produce a difference in displacement of the near and distal tooth

1167

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1170

LOCALISATION (*continued*)

images, this difference being smaller or larger, respectively according to the position of the teeth.

It should be noted that in employing this form of "shadow shift" technique only half of the normal full exposure time should be given from each tube position **(1091b)**, page 430

Extra-Oral

Extra-oral technique is shown in detail in Section 10, in which the mandible is discussed, and reference should be made to that section. As the dental unit is not there shown, however, two positions are given here.

LOWER JAW (1)

A small table is placed beside the dental chair, and the patient, leaning over, allows the head to make contact with the cassette **(1167)**. For the molar region the tube is centred two inches below the angle of the jaw and angled 20 degrees toward the head **(1169)**; for the canine and incisor region the face is turned slightly toward the film and the tube angled also 10 degrees toward the face **(1170)**. This allows the upper molar region also to be disclosed. Reference should be made to pages 202 and 203, in which angle board technique is also discussed **(1167, 1169, 1170)**.

LOWER JAW (2)

In the absence of the table, the cassette, resting on the head support of the dental chair, may be held in position by the patient, the tube being angled 30 degrees toward the head and centred 2 inches below the angle of the jaw to give separation from right to left **(1168, 1169)**.

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
*55	6	4	15″	Ilford	Tungstate	—

Cone to size of film, 6½ × 4¾ in. or 8½ × 6½ in.

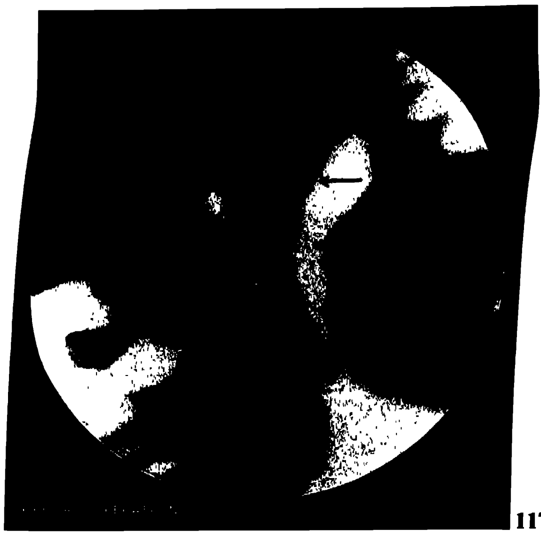
* Dental unit.

Fracture technique is specially referred to under *Mandible* on pages 205 and 207.

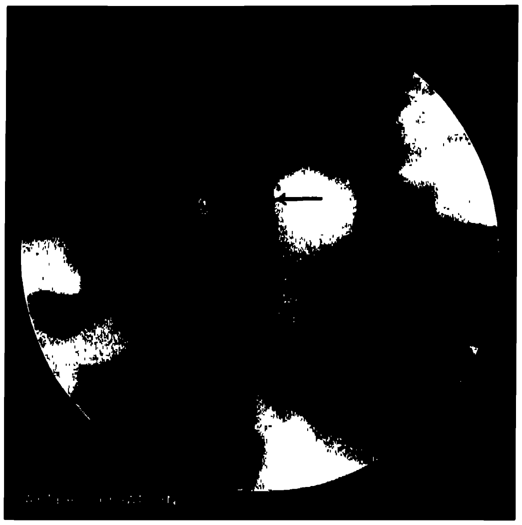
Profile views, to show soft and bone structures, are shown under *Facial Bones*, on page 191. These films are sometimes taken to check possible profile variation which may occur between the extraction of teeth and the provision of artificial dentures.

SECTION 29

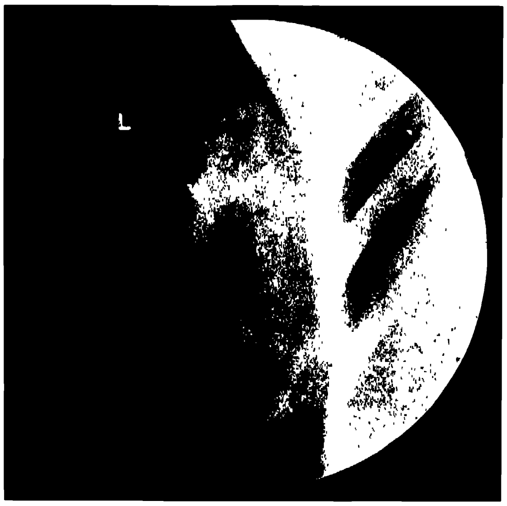
Soft Tissue



1173



1174



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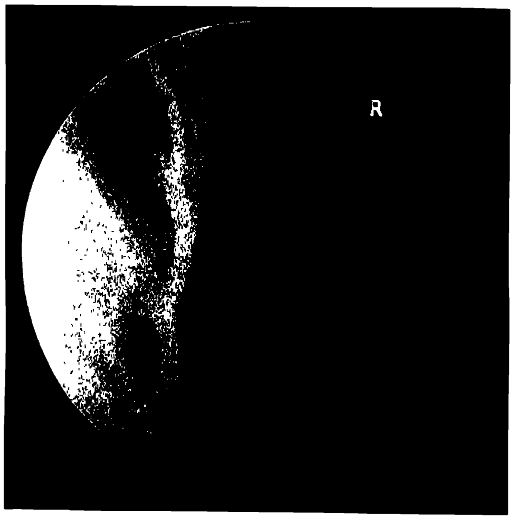


1176

SECTION 29

SOFT TISSUE

As in many of the foregoing sections some reference is made to soft tissue technique, this section is intended to include only such conditions as have not been previously discussed. Actual positioning having been mentioned elsewhere, the illustrations are radiographs only.

Adenoids

Two films exposed from the lateral aspect of the upper pharynx show the naso-pharynx and adjacent soft structures before **(1173)**, and after **(1174)**, an operation for the removal of adenoids. The lateral position of the head and neck is assumed, with the chin slightly raised.

CENTRE below the zygomatic bone.

(1173, 1174)

Positive reproductions in this case replace the negative illustrations generally shown.

EXPOSURE FACTORS						
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	16	10	30″	Ilford	Tungstate	Potter-Bucky

Mammary Glands

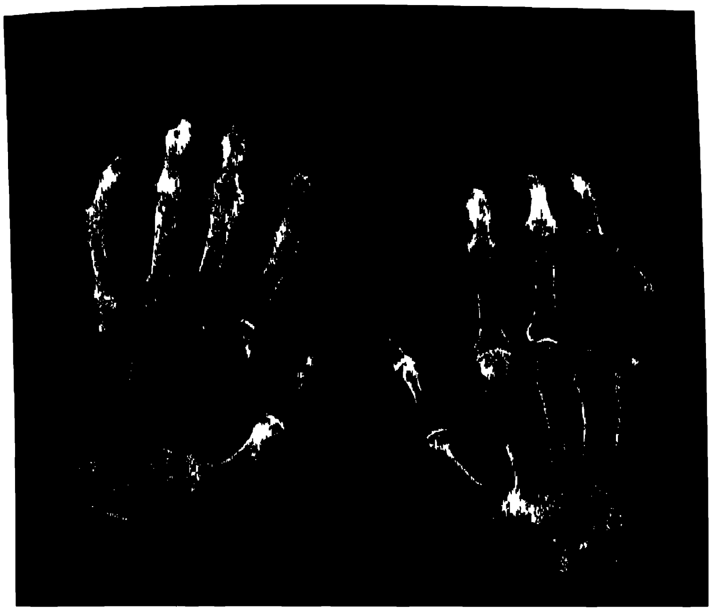
Examination of these soft tissue structures, although as yet not very frequently undertaken, offers no difficulty when suitable exposure factors are applied. The tendency is to over-expose, but by using the Ilfex non-screen film adequate contrast may be obtained while taking advantage of considerable exposure latitude. The patient assumes a reclining position, turning the unaffected side away from the tube so that the beam only penetrates the breast or region under examination **(1175, 1176)**.

Large and pendulous breasts may be examined with the patient suspended in a cradle so that the breast is pendulent from the chest wall, the exposure being made with the X-ray beam projected horizontally. To outline the mammary ducts an injection of Thorotrast may be made, but repeated injections of this substance should be avoided.

Soft Tissue

MAMMARY GLANDS (*continued*)

1175, 1176	EXPOSURE FACTORS					
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
45	116	70	36″	Ilfex	—	

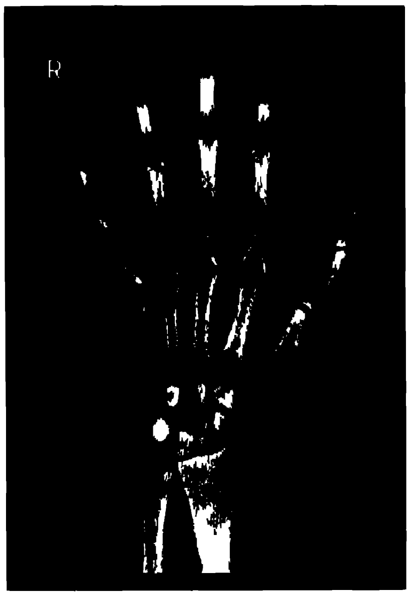


1177

Limbs

It should be noted that in conditions involving bone and surrounding soft tissues the kilovoltage applied should be relatively high, in order that while the bone structure is shown in adequate detail the soft structures may also be demonstrated satisfactorily. At a low kilovoltage exposure sufficient to produce brilliant bone contrast fails to show the soft tissues, these being grossly over-exposed.

Comparison of radiographs **(1177)** and **(1178)** should be made. Reference should be made also to radiograph **(1178a)** exposed to show the soft tissues of the forearms.



1178

1177, 1178	EXPOSURE FACTORS					
	mA. Secs.					
kVp.	Ilford X-ray	Developers Blue Label	Distance	Film	Screens Ilford	Grid
70	10	6	30″	Ilfex	—	—
40	132	80	30″	Ilfex	—	—

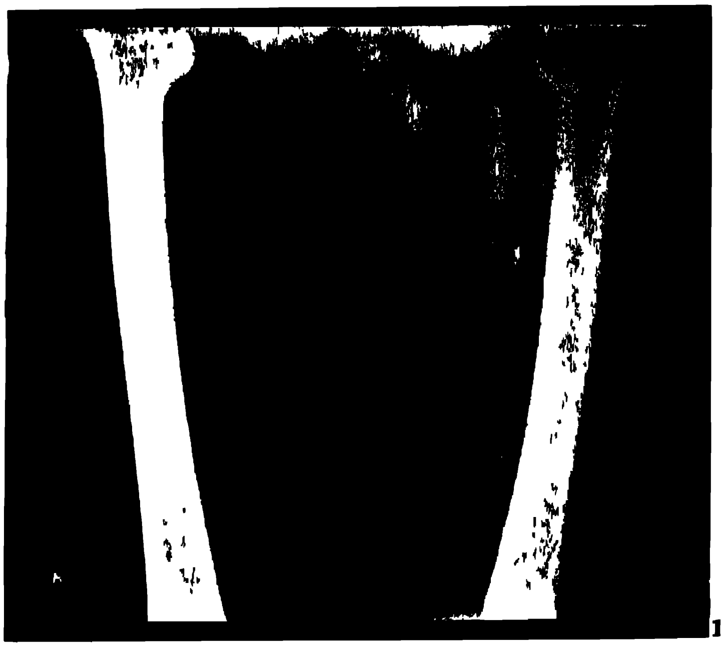
1178a

Multiple, but only slightly opaque, shadows, such as those shown in **(1178b)** may require the use of the Potter-Bucky diaphragm. This is especially so in the case of the thick tissues of the thighs, in demonstrating which both limbs should be exposed simultaneously, a 17 inch by 14 inch film, placed transversely, being used.

In the condition such as that illustrated, namely, cysticercosis **(1178b)** and also **(1178a)** the patient is X-rayed extensively, limbs, trunk and head being included in the examination.

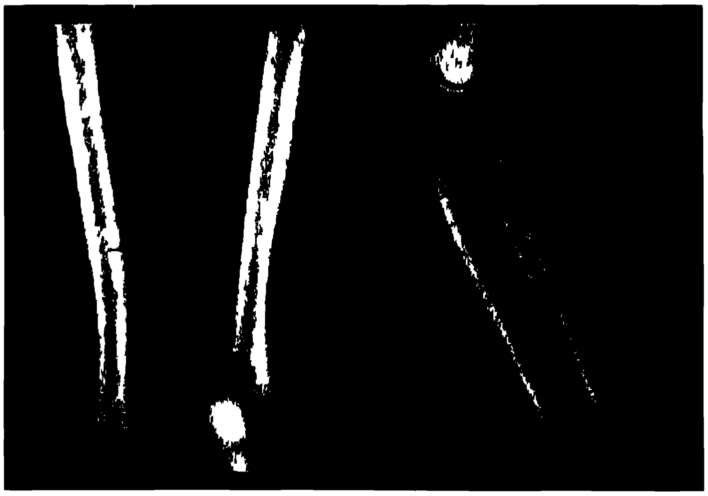
It follows, therefore, that the choice of exposure technique should be suited to the condition to be investigated. It should be emphasised, moreover, that in exposing a series of radiographs of the same patient at intervals throughout a period, there should be no variation whatever in exposure and development technique, in order that *true* comparison may be possible. This applies also,

Soft Tissue



1178b

1178c



1178d

1178e

LIMBS ***(continued)***

of course, to the periodic investigation of the lungs and of bone conditions such as rickets and surgical tuberculosis; and for the latter group a small aluminium step wedge may well be placed on each film as a check on standardised conditions.

Thighs	EXPOSURE FACTORS					
	mA. Secs.					
kVp.	Ilford Developers X-ray	Blue Label	Distance	Film	Screens Ilford	Grid
55	66	40	36″	Ilford	Tungstate	Potter-Bucky
75	—	194	30″	Ilfex	—	Potter-Bucky

Other Conditions giving rise to Soft Tissue Shadows

Under favourable circumstances shadows in the soft tissues may also be formed by any of the following conditions:—

Calcification of the walls of the arteries, as described on the following page **(1179, 1180, 1181)**.

Cyst, a tumour containing fluid or solid substance, which in the latter state, depending on the region concerned, may be visible on a soft tissue radiograph. Calcification in the wall of a cyst renders it opaque to X-rays, presenting an annular appearance as shown in **(1182)**.

Hæmatoma which, if the blood is not absorbed, later calcifies and thus becomes visible.

Lipoma, a fatty tumour that is more transradiant than the other tissues and which appears, therefore, as a dark shadow on the film.

Any appreciable *loss of soft tissue mass*, which appears as a denser shadow in the tissues **(1178e)**.

Myositis ossificans, the formation of bone in the muscles **(1178d)**: as a local condition it occurs at the site of pressure or repeated trauma and in the region of fractures and dislocations: there is also a generalised condition, but this is very rare. Bone may also be formed in operation scars, especially of the abdominal wall.

Neurofibromas and other soft tissue tumours may cast a shadow or reveal their presence by the deformity of the skin surface outline, or by the displacement or deformity of adjacent normal soft tissue structures.

1179

Soft Tissue

OTHER CONDITIONS GIVING RISE TO SOFT TISSUE SHADOWS (*continued*)

Phleboliths These are clots or thrombi in the veins which have become calcified, forming small, round or oval shadows They are most frequently seen in the veins of the pelvis on one or both sides **(1178c)**, they may be single or very numerous, and may be considered a normal condition in later life Clots and phleboliths in the subcutaneous veins of the limbs may also be clearly shown

Surgical emphysema **(1181a)** or gas gangrene, which shows as numerous black shadows in the tissues Reference should be made to *Foreign Bodies*, page 417.

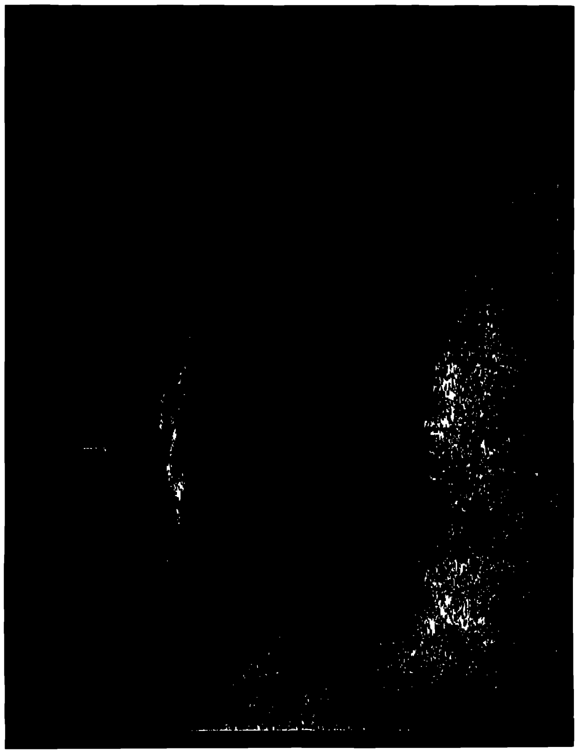
ARTERIES

When the walls of the arteries become visible, due to calcification, an examination of the limbs should include films to cover the course of the arteries concerned from their main trunk origin to distal extremities Views from one aspect only are usually sufficient, a reduction in either kilovoltage or exposure time being made according to the conditions obtaining

The illustrations indicate the presence of calcified arteries in pelvis, leg and foot **(1179, 1180, 1181)**

1180

1181



1181a

1182

Soft Tissue

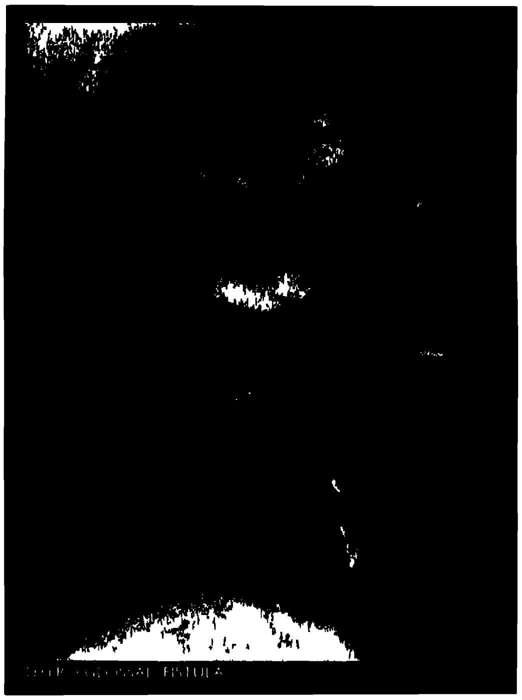
Injection of Iodised Oil

It is sometimes necessary to make a radiographic examination following an injection of iodised oil into sinuses and festulous tracts in the soft tissues leading to cavities or bone lesions. As previously discussed, the success of these examinations depends on the technique of injection, it being essential that the films should be exposed while pressure on the syringe is maintained **(1184)**.

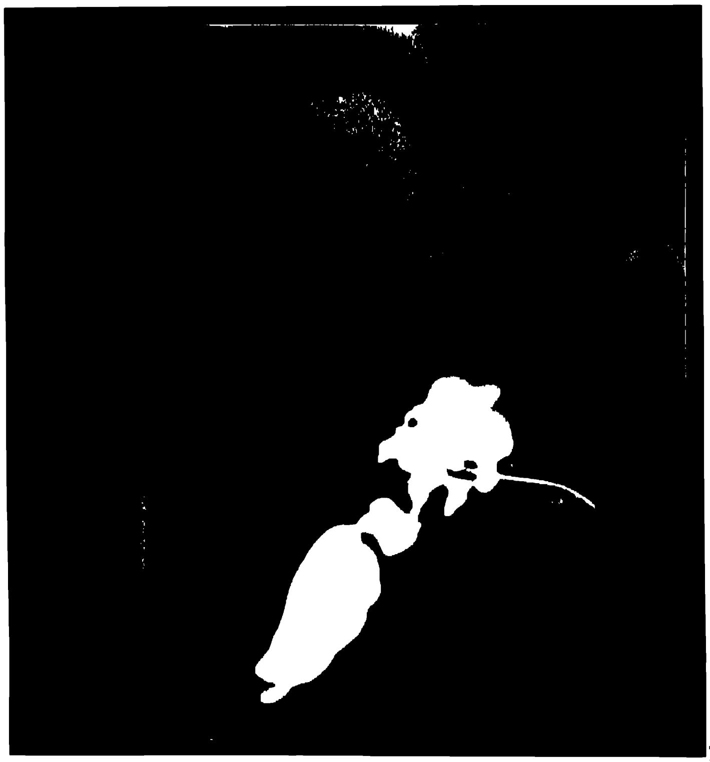
When conditions are suitable, exposures are made from both antero-posterior and lateral aspects of the limb and may sometimes be stereoscopic. The position of the skin exits of such sinuses may be shown on the films by small metal rings placed on the skin surface. A radiograph of the hip joint shows the appearance after injection of iodised oil with sinus exit rings in position **(1184a)**, stereographs in this case being of considerable value.

THYRO-GLOSSAL FISTULA

A canula is inserted into the tract at the skin opening of the fistula, which in the case illustrated **(1183)** is at the crico-thyroid level. 3 to 7 cubic centimetres of iodised oil is injected at blood heat, pressure being maintained on the syringe during the exposure, which is made from the lateral aspect of the neck—soft tissue technique is employed **(1183)**.



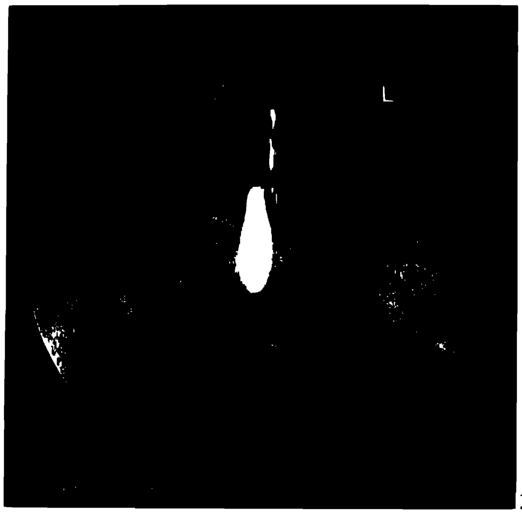
1183



1184

SECTION 30

Myelography



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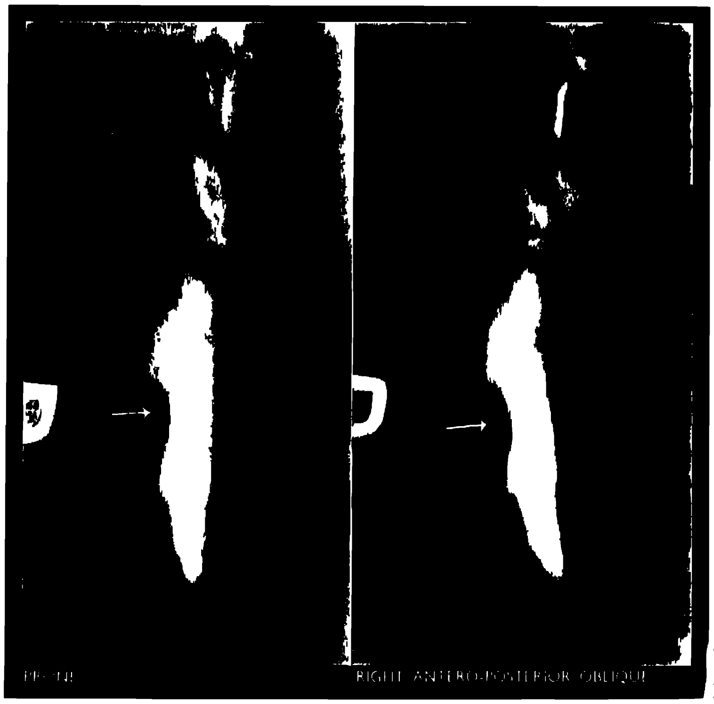
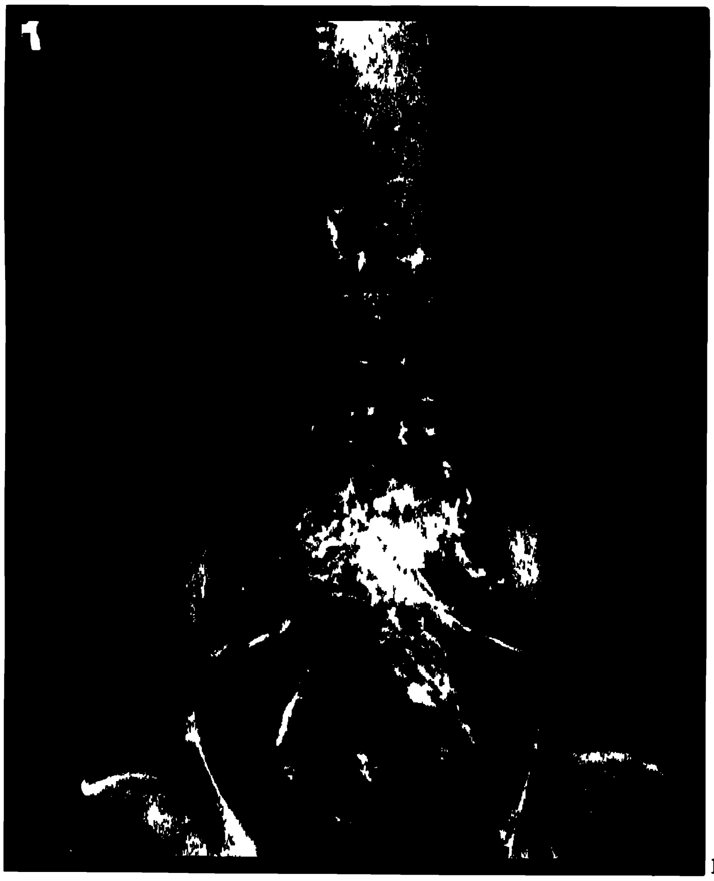


1185a
1185b



1186

SECTION 30

MYELOGRAPHY

Myelography, the radiographic investigation of the spina cord, is undertaken for the purpose of demonstrating th condition of the membranes and of examining an encroachment upon or obstruction of the spaces betwee and about them, the investigation being made after in jection of iodised oil or air into either the sub-arachnoi or the epidural space surrounding the spinal cord.

The spinal cord is surrounded by three membranou coverings having between them two unequal spaces Between the innermost membrane, or pia-mater, an the second, or arachnoid, is the *sub-arachnoid spac* containing cerebro-spinal fluid; the smaller space betwee the arachnoid and the outer membrane, or dura-mater is termed the subdural space. The dura-mater is separate from the wall of the vertebral canal by the *epidura cavity*, containing loose connective tissue, veins and fat.

The Sub-arachnoid Space

Using either a sub-occipital or a lumbar point of entry an injection of from 2 to 5 cubic centimetres of iodised oi is made into the sub-arachnoid space, and the oil will mov freely along the space unless arrested by an obstruction the site of which thus becomes clearly visible.

It is necessary to the success of the examination that th iodised oil should not divide into globules and the patien is, therefore, maintained in the sitting position during th period from the injection being given to the commencement of the X-ray examination.

The use of a tilting couch is essential to enable controlled movement to be applied during screen examination.

The iodised oil, which is heavier than the cerebro-spinal fluid, will slowly sink to the lowest level of the cavity—to the mid-sacral region when the patient is erect, following the sub-occipital injection, and to the cervical region, following the lumbar injection, when the position of the patient is reversed and the head considerably lower than the sacrum. The screen examination may take place immediately after the injection and is followed by films as required. Should the iodised oil not pass freely along the canal the cause of obstruction is further investigated from various aspects, the examination being repeated the following day. Under normal conditions, by tilting the patient longitudinally the opaque globule may be seen moving from end to end of the spine **(1185)**.

THE SUB-ARACHNOID SPACE (*continued*)

For a general examination the positions employed may include antero-posterior and postero-anterior, with the patient prone or supine; also right and left lateral and oblique, as required, exposures being made with the tilting couch at the angle which screen examination may have indicated as being most suitable. When air is injected in place of the iodised oil the patient is positioned to allow the air to rise to the level of the area to be demonstrated.

INTERVERTEBRAL DISCS

This technique, usually by injection of iodised oil at the level of the second to third lumbar vertebræ, is applied also for the demonstration of any slight intrusion into the spinal canal of an intervertebral disc, a condition which is indicated in the radiograph by an indentation in the outline of the iodised oil.

The examination commences with the patient in the erect position, the couch being then gradually lowered to allow the region of each separate disc to be subjected to screen examination from antero-posterior and right and left oblique aspects. Movement of the couch through 110 degrees from the vertical usually enables full examination of the lumbar region to be made, but for the dorsal and cervical regions it is necessary to reverse the position of the patient on the couch and to provide supports for head, shoulders and feet to enable the head to assume a level considerably below that of the feet. It should be realised that in order to demonstrate such irregularities it is essential that the patient be so placed as to ensure the iodised oil falling on to the posterior surface of the vertebral bodies and intervertebral discs. Thus, with the patient in the *prone* position films are exposed from the antero-posterior aspect, using the under-couch tube **(1185a)**, and from the lateral aspect with the X-ray beam directed horizontally. Other views are taken from the right and left antero-posterior oblique positions, the patient being turned slightly on to the right **(1185b)** and left sides in turn.

Positioning rotation of the trunk and degree of angle of tilt of the couch are determined by the conditions disclosed by the screen examination. Careful identification of the right and left sides of the spine is imperative.

The Epidural Space

This space is not as frequently injected as the sub-arachnoid, although the one investigation may embrace both injections.

4 to 5 cubic centimetres of iodised oil are injected at either the sub-occipital or lumbar level. The iodised oil splits up and mingles with the fatty substance in the cavity, and eventually tends to pass through the intervertebral foramina. The X-ray examination by screen and film takes place 4 to 5 hours after the injection **(1186)**.

SECTION 31

Stereography

STEREOGRAPHY

The stereoscope is an instrument which by means of a simple lens or mirror arrangement causes two views of the same object, taken from slightly different points, to appear as a single image possessing a certain "depth" absent in the normal flat view.

Stereographic films are of great value in certain cases, particularly when it is not practicable to take two views at right angles to each other. They are made by exposing two films, object and film being in the same position in both exposures but the anode positions being slightly different—another application, in fact, of the "tube shift" technique.

The patient having been immobilised, the tube is centred, usually from an anode-film distance of 25 inches, and the two films exposed from diametrically opposite points each 1¼ inches from the central position **(1187)**. This tube-shift of 2½ inches is employed because it is the average inter-pupillary distance, the anode-film distance of 25 inches being adopted as the most convenient distance for use between films and mirrors in the stereoscope **(1188)**.

The anode-film distance may be increased, when the tube shift also should be increased, its value being maintained at one-tenth of the anode-film distance.

In general radiography it is possible to immobilise the patient so that movement during the changing of films is reduced to a minimum, in which circumstances tube movement may be controlled by hand. In chest work, however, the two exposures must be made with the least possible interim delay, there being inevitable movement during respiratory or cardiac action. Where stereoscopic films of the chest are made as a matter of routine, therefore, the use of apparatus incorporating mechanical tube-shift and film-change is advisable.

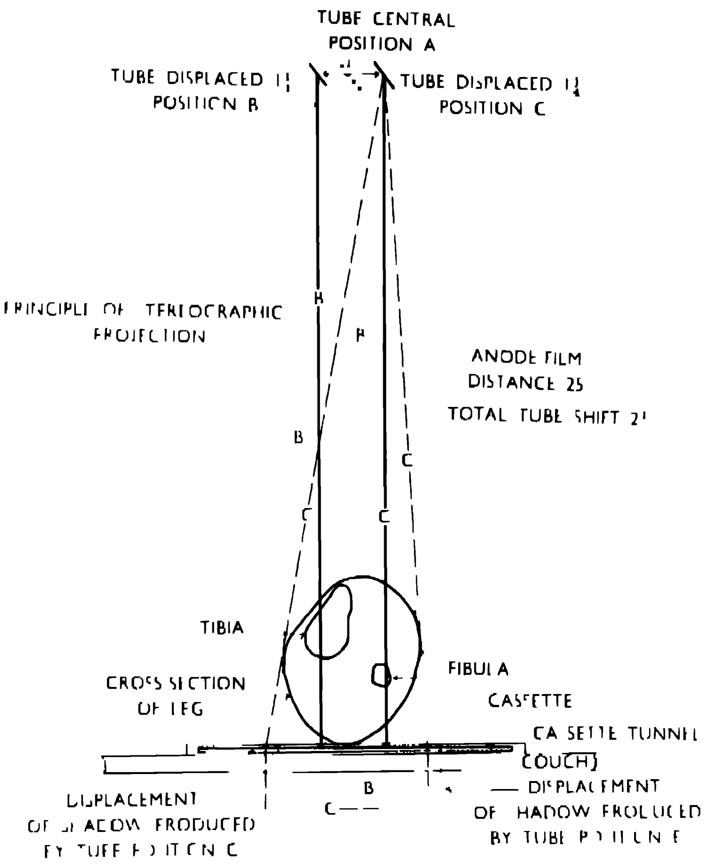
In using the tube without the cone it is not necessary to tilt the tube, but when the localising cone is used the tube should be angled toward the centring point from both positions.

It should be emphasised that each pair of films should be treated as a unit and both films, therefore, taken and processed under identical conditions.

The films should be placed in the stereoscope so that they may be seen as the object appeared from the tube position. In the ordinary binocular type of instrument they are placed side by side in the viewing box. In the mirror type, however, in which the films should be the anode-film distance from the mirrors, care is necessary to place them correctly. The films show a slight image-shift --it may be necessary to place them one over the other to detect this—and as the exposure made at one side of the centre line projects the image to the opposite side of that line, the film showing the image the more to the *left* is placed in the *right-hand* viewing box, and *vice versa*. It should also be remembered that as the mirrors reverse as well as reflect, the films should be reversed in the boxes **(1188)**.

Of the many types of stereoscopes available the Wheatstone is perhaps the most commonly used. The distance between viewing boxes is adjustable and the angulation of the mirrors is variable to suit the eyes of the user; the mirrors may be moved across the inter-viewing box line to bring the image into focus, and may be raised or lowered as may be necessitated by the size of the films **(1188)**.

In taking stereographic films the direction of the tube-shift should be at right angles to that of the predominating lines of the part being examined: when the long bones are the subject the tube moves at right angles to the long axis; in the case of the chest, where the ribs are the dominant lines, the movement is along the line of the vertebræ, while if the spine is being examined the tube moves across the trunk. In certain exceptions, such as the skull, the direction depends upon the precise area being investigated, it being borne in mind that as the purpose of stereography is to secure an impression of perspective the two exposure points should be chosen with that aim in view.



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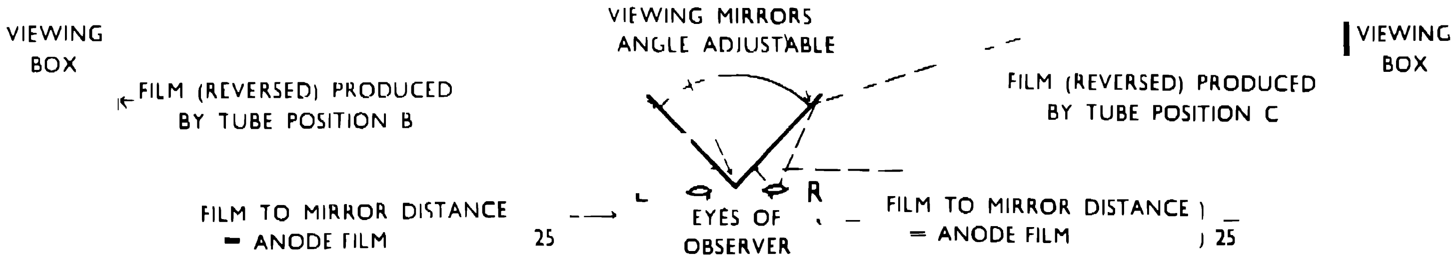


PRINCIPLE OF THE WHEATSTONE STEREOSCOPE

1188

SECTION 32

Cineradiography

CINERADIOGRAPHY

Although not yet widely practised, partly perhaps, because its particular value and great potentialities have not hitherto been generally appreciated, cineradiography has already been adopted by a number of workers as an additional routine aid to diagnosis, and it cannot be doubted that the technique will become established as a definite diagnostic method in suitable cases. Excellent cine films have been obtained of practically every moving part of the body—skeletal joints, lungs, heart, alimentary and renal tracts.

There are two methods, the "direct" and the "indirect." Briefly, the former depends on the taking of a series of full-sized radiographs in rapid succession, the series being transferred to 35 millimetre standard size cinematograph film for projection.

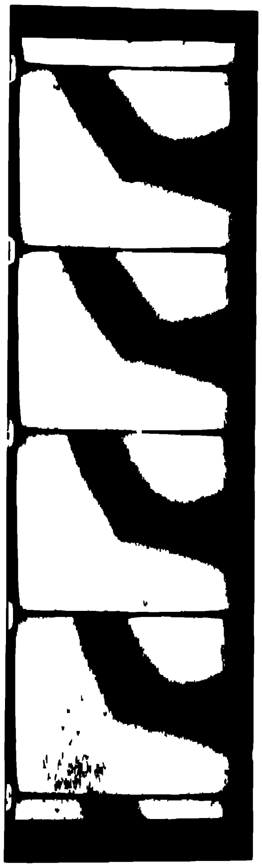
By the "indirect" method photographs of the image seen in the fluorescent screen are made on a 16 millimetre substandard cinematograph film at the rate of 6 to 25 frames per second, each frame, or length of film measuring 16 by 11 millimetres, constituting a single exposure. There are approximately 1,200 frames in each 100 feet of film, and approximately 3 feet of film is used for each recording.

An automatic exposure switch, operating in conjunction with a circuit breaker in the generator circuit, allows the X-ray tube to be energised only when a frame is in position in the camera, and as this is arranged to occupy only half the total time of operation, the patient's exposure to X-radiation is similarly reduced.

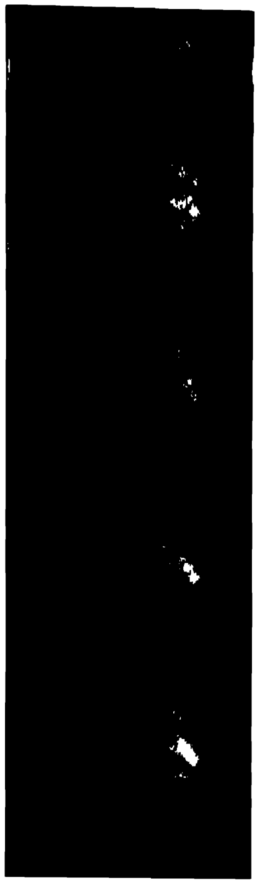
The number of frames per second is varied according to the speed of movement of the region involved, the ankle and elbow, for example, requiring 25 frames per second, and the stomach only 3 to 6 frames per second.

A total camera time of 10 seconds is sufficient for each recording, and the patient is exposed for only 5 seconds. This, at 60 milliamperes, allows 300 milliampere seconds, which is no more than is given for many ordinary radiographic exposures, and which, applied at a 30 inch anode-film distance, at 90 kilovolts to 110 kilovolts, produces only 21 r to 36 r at the nearest tube-skin surface.

For viewing, the ends of the short length of film are joined together and the series of exposures passed through the projector as a continuous band.



1189



1190

Two illustrations, showing the elbow joint and the lungs, respectively, have been enlarged to twice the actual size of the original 16 millimetre cine film (1189, 1190).

The X-ray unit specially designed for cineradiography can be used also for general radiographic work.

SECTION 33

X-ray Screen Photography

X-RAY SCREEN PHOTOGRAPHY

Photographic recording of the X-ray fluorescent screen image may take the form of:

(*a*) *Cineradiography*—a method of making a rapid series of exposures of one subject which, on projection, forms a "moving" picture;

(*b*) *Mass miniature radiography*—the recording of a single exposure of each subject—so called because of the ease and economy of its application to more or less large numbers of subjects.

Cineradiography by both direct and indirect methods has been described briefly in the previous section.

Mass Miniature Radiography

Mass miniature radiography, also referred to as fluorography, is similar to the indirect method of cineradiography, except that it is concerned only with the taking of "stills" of the fluorescent screen image; and while the question of definition is of even greater importance than in cineradiography, the procedure in miniature radiography is simpler because only one exposure of each subject is required.

Before undertaking this work, however, it is essential to appreciate the necessity for a very high standard of quality and uniformity of result, and to realise also its limitations. At present nothing can replace in precision and completeness the radiological investigation of the lungs by a combination of fluoroscopy and direct radiography, but miniature radiography does, nevertheless, render possible an intermediate form of examination which has the great advantage over screening alone of providing, in comparatively short time, permanent records of many subjects.

Mass miniature radiography is at present applied to the examination of the chests of large numbers of people who otherwise would not be examined, and it permits of the rapid survey of the inhabitants of a district, of large groups of workers, or of members of the armed forces. It has been found in such surveys that approximately 0·04 per cent. of those examined are in need of immediate treatment, although as many as 2 per cent. may be given medical advice. It is beyond doubt that the information gained by this form of investigation has shown the desirability for its wider adoption.

GENERAL PROCEDURE

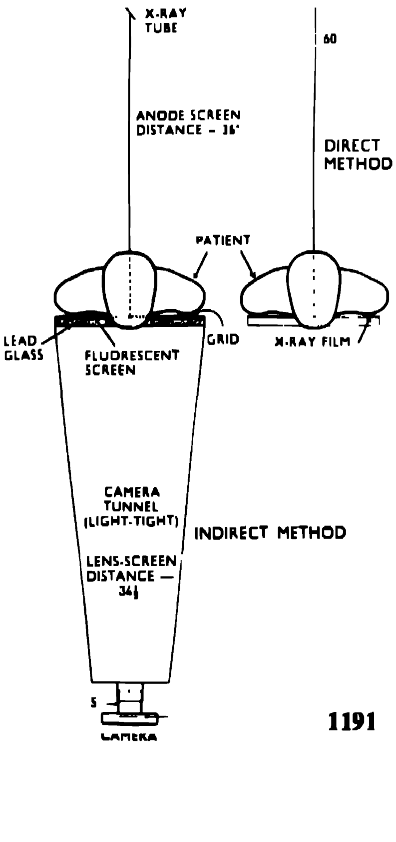
Briefly, the image shown on the fluorescent screen is photographed on a small film, which may vary in size from 35 millimetre standard cine film, giving a one-inch square picture, to 5 inches by 4 inches, the smaller size being more generally used for mass examination, where speed is imperative. Its use is further indicated by the difficulty of obtaining lenses of sufficiently large aperture to give good definition over the whole area of the larger film.

The subjects are examined in the erect position, the whole apparatus being designed to facilitate positioning and the quick passage of each person, and at the same time to provide full protection for the operator against X-radiation.

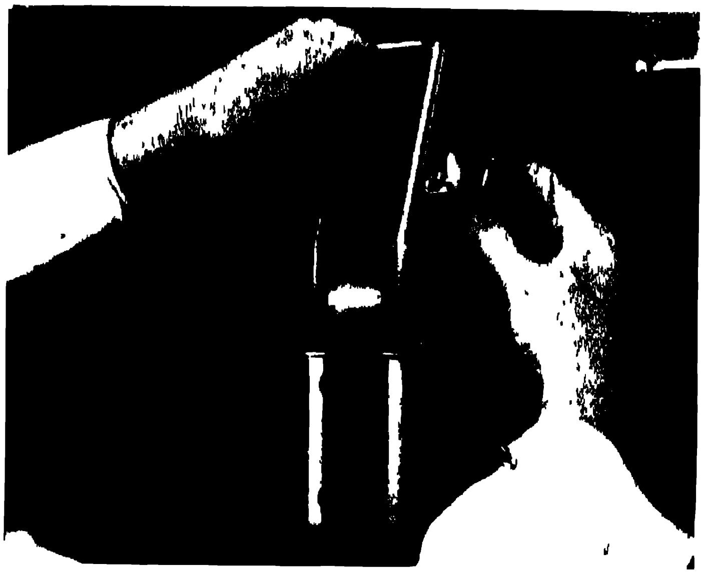
Experience has shown that following the miniature film examination it is necessary to recall from 5 per cent. to 7 per cent. of the subjects for re-examination on large films, approximately 2 per cent. being subsequently recalled for clinical examination.

A plan diagram (**1191**) shows the relative arrangement for taking the miniature (indirect) radiographs and the re-examination large (direct) radiographs.

X RAY
TUBE



1191



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X-ray Screen Photography: Mass Miniature Radiography

X-RAY EQUIPMENT

Apparatus for miniature radiography may be considered briefly in three parts—the X-ray Power Unit, the Camera Unit, and the Control Table.

POWER UNIT

The Power Unit consists of a four-valve transformer built for transportability and having an output of at least 200 milliamperes at 95 kilovolts-peak. The unit is fitted with a rotating anode tube having a focus not exceeding 2 millimetres square: an adjustable diaphragm enables the tube aperture to be varied to suit the several X-ray focus-screen and focus-film distances required for miniature and large films.

CAMERA UNIT

The Camera Unit consists of a light-proof pyramidal-shaped tunnel fitted at the smaller end with the camera and at the larger with the fluorescent screen, protective lead glass and radiographic grid. The tunnel also carries the identification device. The camera accommodates 82 feet of miniature film (**1192**), movement of the film in the camera, following each exposure, being controlled automatically from the switch table: a cutting device enables the exposed length of film to be divided into suitable lengths for removal in the take-up cassette for subsequent development. The camera is fitted with a fluoride-coated 2-inch $f/1{\cdot}5$ lens. The coating of the surfaces of the lens eliminates internal reflection and thus ensures maximum definition, contrast and speed. Focussing of the lens is a precision adjustment which is made when the unit is installed.

The *fluorescent screen*, of the Levy-West Yellow-Green type, is 16 inches square so that it may include the whole of the largest chest, there being some enlargement of the screen image owing to the short focus-screen distance employed, which is usually 36 inches. To reduce scattered radiation, thereby improving definition and contrast, and also as a protective measure, the tube diaphragm is adjusted to limit the X-ray beam to the area of the screen and lead glass.

The *protective lead glass*, which is on the camera side of the screen, absorbs approximately 10 per cent. of the fluorescent screen illumination, but this is not considered to be a sufficient loss to warrant its disuse. Indeed, this relatively small loss in speed is of little consequence and is far outweighed by the protective value of the lead glass.

A *stationary grid* of suitable characteristics is used to reduce scattered radiation, which, if allowed to reach

X-ray Screen Photography: Mass Miniature Radiography

CAMERA UNIT (*continued*)

the screen, would cause diffusion of detail and loss of contrast, thus spoiling definition and giving the appearance of a general veil on the radiograph, which would become particularly objectionable on projection. The grid is placed in contact with the back of the fluorescent screen, and is therefore between the patient and the screen. The grid lines are not visible on the film or on projection. A higher kilovoltage is used to compensate for the use of the grid.

Identification of chest radiograph with subject is achieved by photographing on to the lower border of the radiograph the serial number on the individual's record card (**1193**) which is placed in a slot provided on the apparatus, the exposure being made automatically. It should be noted that the apparatus cannot function unless the record card is placed correctly in the identification device.

Correct alignment between X-ray tube and screen is important and may be checked by means of an optical centring device. Simultaneous adjustment of the level of the two units X-ray tube and camera tunnel—to suit the varying heights of the examinees is obtained in the one unit by the use of a flexible cable system (**1194**).

THE CONTROL TABLE

The Control Table is so constructed that, the appropriate exposure having been set, the single control switch operates automatically in sequence, the rotor of the X-ray tube, the light exposure of the number on the record card in the identification device, the X-ray exposure and, on exposure being completed, the movement of the film in the camera. Meters and light indicators enable the operator to detect failure in any part of the apparatus, and limiting devices prevent overloading of the X-ray tube.

Protection for the operators takes the form of two protective screens fitted with lead glass viewing windows (**1194**).

EXPOSURE TECHNIQUE

The light from the fluorescent screen is so much less effective than direct X-rays with intensifying screens that it is necessary to increase the normal X-ray exposure factors by as much as four or five times. The focus-*film* distance for the direct radiographs is therefore reduced from approximately 6 feet to 3 feet focus-*screen* distance for the miniature radiographs and the kilovoltage is increased by 20 to accommodate the additional output required for the radiographic grid.

As its name implies, mass miniature radiography i undertaken with a large number of subjects and, therefore the need for satisfactory organisation and uniformity o result becomes imperative. It is essential that the stat should work as a team and, within limits, be able t interchange readily.

As the unit is transportable, to be set up in premise where large numbers of workers are employed, unless a mobile generator is available the electric mains supply i a very important item and becomes, indeed, the first con sideration of a visiting mass radiography team.

With examinations being made at the rate of 500 pe day, and working to standard development of the film strips, standardised exposure to produce uniformity o results assumes great importance, and is achieved by basing the exposure technique on the chest thickness measurement.

MEASUREMENT OF CHEST THICKNESS

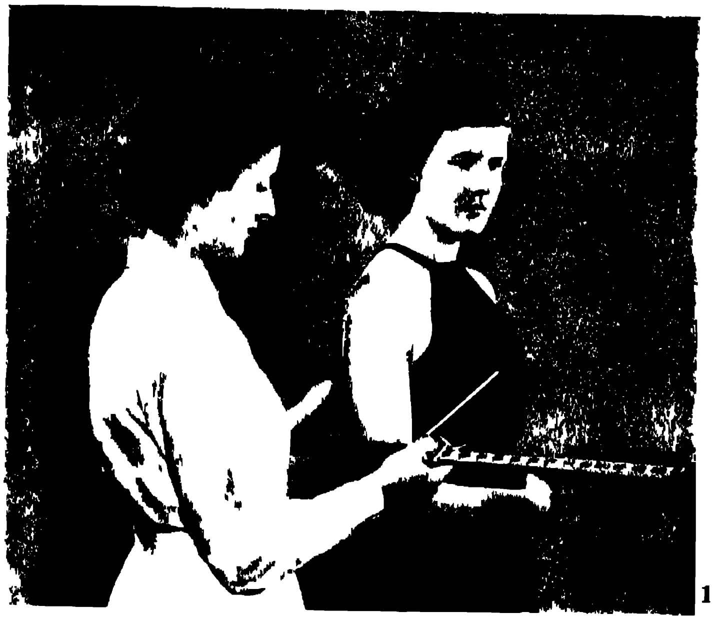
The chest measurement, which is made with a pair of specially designed calipers, is taken over the thickest part of the subject, and will be found to vary as to level particularly as between men and women (**1195, 1196**) Uniformity in measuring chest thickness having been reached, the operator at the control table is able to work to a set exposure table. (See pages 489, 491.)

Working to the nearest half-inch on the scale, 2 kilovolts are allowed for each half-inch increase within the average measurement range of from 8 inches to 10 inches, the exposure time remaining constant at 0·1 second. Below 8 inches in thickness, however, a further *reduction* in kilovolts would produce undue contrast in the chest picture and the necessary adjustment is therefore made in exposure time, namely, a reduction of 0·01 second for each half-inch in thickness. On the other hand, at thicknesses above 10 inches a further *increase* in kilovolts would give insufficient contrast, and therefore a compromise is made between kilovolts and exposure time, the increase being chiefly in time, as shown in the table on page 489. This method of exposure according to subject thickness enables the operator to produce *uniform* results of *very high quality*, both of these factors being essential for satisfactory viewing of the enlarged chest radiographs by the radiologist.

The thickness measurement is written within the number space on the record card, a soft pencil being used: it therefore appears on the film as a permanent indication to the radiographer of the exposure conditions employed and to the radiologist as a guide to the type of subject concerned.

With the establishment of such systematised exposure technique under given standard conditions any variation

1195



1196

MEASUREMENT OF CHEST THICKNESS (*continued*)

in quality of result which may occur, for example, on a move being made to a new centre, may at once be met by a uniform adjustment of exposure throughout the thickness scale. Indeed, at the outset of each survey each of the first series of trial examinations should be made at *two* exposure settings, the first according to the standard exposure table and the second with an increase of 4 kilovolts, or an alternative increase in time. From the radiographic results the condition of the electric supply may be judged and any necessary adjustment made for subsequent exposures.

From the exposure table based on chest thickness measurements for miniature radiography a similar table may be prepared for the exposure of large films for the postero-anterior view on the same machine, to which table may be added the conditions required for other views—antero-posterior, lateral, lordotic, oblique, and special views with the stationary grid. Such tables have been employed during 18 months' work on miniature radiography and their reliability amply proved by the very high standard of uniformity and quality of the many thousands of radiographs produced, many of which were taken at the rate of more than 500 per day.

EXPOSURE CONDITIONS FOR MINIATURE AND LARGE FILMS

X-ray Unit:	4-valve. *Maximum* output not less than 200 mA and 95 kVp.
Tube	Rotating anode with *maximum* 2 mm. square focus.
Fluorescent screen	Levy-West (yellow-green) Mark 39 with lead glass protection.
Lens:	2-inch, *f*/1.5 fluoride-coated.
Radiographic grid	50 slats to the inch with a speed factor of 3 to 1
X-ray tube-focus to *screen* distance.	36 inches for *miniatures*
X-ray tube-focus to *film* distance.	60 inches for *large films*
Camera lens to screen distance	34½ inches, approximately, for a 16 to 1 reduction.
Kilovoltage: (allowing 6 inches to 13½ inches chest thickness).	78 to 90 kVp for *miniatures*. 55 to 80 kVp for *large films*.


1197


1198


1199

X-ray Screen Photography: Mass Miniatur Radiography

EXPOSURE CONDITIONS FOR MINIATURI AND LARGE FILMS (*continued*)

Milliamperes:	200 for *miniatures* 300 for *large films*	
Exposure time: (For average—8 to 10 inches — chest thickness)	0·1 for *miniatures* 0·07 for *large films*	20 m/ secs.
Film:	35 millimetre Ilford H.P.X. (Fin Grain Hypersensitive Panchro matic).	
Developer:	Ilford Blue Label Developer.	
Developing time:	*Miniatures*—8 minutes at 6 degrees Fahrenheit. *Large films*—5 minutes at 6 degrees Fahrenheit.	
Viewing:	*Miniatures*—on projection to inches by 5 inches square witl 100-watt projector lamp. *Large films*—by evenly illumin ated viewing box.	

POSITIONING

In miniature radiography the short focus-screen distanc renders positioning critical. In a well-designed unit th positioner is able to move freely behind the subject positioning for symmetry being thus simplified. Th subject is "moulded" to the screen by pressing th shoulders downward and forward, the arms being adjuste in the most satisfactory position to enable the clavicles t be depressed and the shadows of the scapulæ to be pro jected outside the lung field. It should be remembere that when working at a distance of 36 inches the smalles fault in positioning is magnified in the radiograph, and th utmost care should therefore be taken to follow closely th positioning described and shown on page 311. See als (**1197**) showing the hands at waist level as is necessary witl subjects having *short* arms; (**1198**) with the arms extended brought forward and rotated, as may be necessary fo elderly subjects who are inclined to be stiff, in order t bring the shoulders near to the screen; and (**1199**) with th hands low down over the buttocks as required for subject with long arms.

It should be remembered that the shoulder position is o first importance and that the position of the arms an hands is adapted accordingly.

X-ray Screen Photography: Mass Miniature Radiography

EXPOSURE TABLE FOR MINIATURE FILMS (Postero-anterior position at 36 inches focus-screen distance)

	†Chest Thickness	kVp	*(Stud)	Time in seconds at 200 mA
	6	78	(10)	0.06
	6½	78	(10)	0.07
	7	78	(10)	0.08
	7½	78	(10)	0.09
Exposures	**8″**	**78**	**(10)**	**0.**
for	**8½**	**80**	**(11)**	**0.**
average	**9**	**82**	**(12)**	**0.**
size	**9½**	**84**	**(13)**	**0.1**
subjects	**10**	**86**	**(14)**	**0.1**
	10½	86	(14)	0
		88	(15)	0.12
	.	88	(15)	0.15
		88	(15)	0.17
	.	88	(15)	0.2
		90	(16)	0.2
	.	90	(16)	0.24

* These *stud* values apply only to the standard unit supplied for the National Scheme

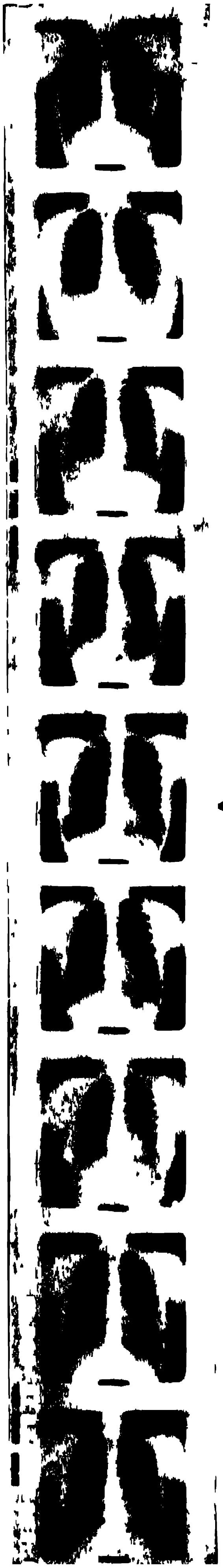
† Measurement taken over greatest thickness of chest

Develop in Blue Label developer for *eight* minutes at 65 F.

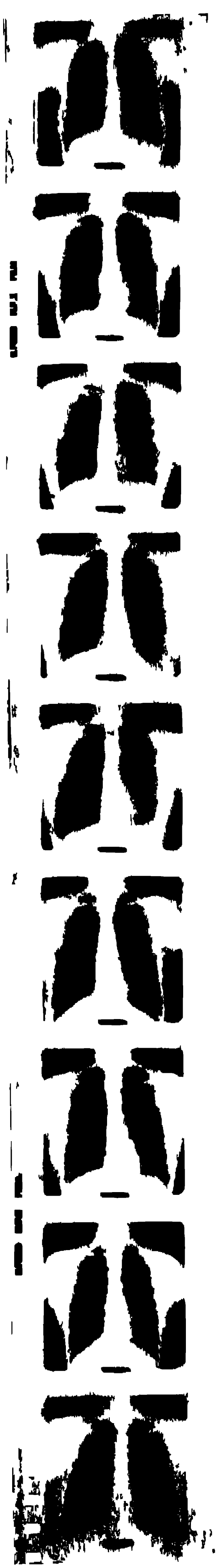
DEVELOPMENT

Development of the miniature film is standardised by employing either a simple form of daylight development tank for short film lengths of 5 feet or, for longer lengths of film up to 25 feet, a special frame which fits into a full-size radiographic developing tank. The use of a fast developer, such as Ilford Blue Label, with the fast fine grain hypersensitive panchromatic (H.P.X.) film serves to reduce the exposure time and to give a clean film with good contrast, which is necessary for satisfactory projection It should also be remembered that the film should not be handled unnecessarily as all blemishes on the film surface are magnified on projection.

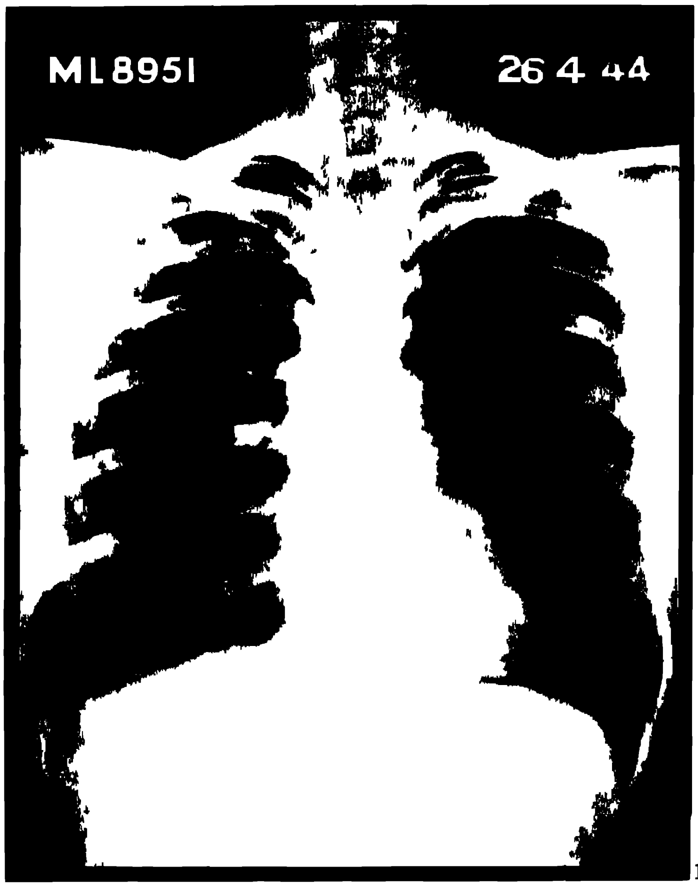
The two strips of miniature radiographs show women in **(1200)** and men in **(1201)**. From **(1200)** miniature ML8951 is shown again in **(1203)**, this subject having been recalled for full-sized films to be taken, as shown in **(1202)** postero-anterior and **(1204)** antero-posterior, a lesion in the right upper lobe of the lung being confirmed.



1200



1201



1202


1203

1204

X-ray Screen Photography: Mass Miniature Radiography

VIEWING

A suitable projector and screen enables the miniature radiographs to be seen at a size of 5 inches by 5 inches or larger, as may be chosen.

It is essential that the projector should have a well-corrected lens, simple mechanism for the easy and scratch-free manipulation of the miniature film, and satisfactory illumination, for which a 100-watt lamp is suitable

The *projection screen* should be of a dead white matt surface When many miniature radiographs are to be examined at one viewing it is found that eye-strain may be reduced by confining projection to the smaller size of 5 inches by 5 inches A further factor is the better definition of lung detail shown in the smaller and more concentrated image, thus enabling the radiologist to sit very near to the screen It is not unusual to "read" these films at the rate of 400 an hour

When numbered at one end and filed in small drawers with cardboard partitions the film records are readily accessible for reference, many thousands of chest radiographs occupying only a very small space

RECALL LARGE FILM EXAMINATIONS POSTERO-ANTERIOR

The result of viewing the miniature chest radiographs is to show, as already mentioned, that in approximately 95 per cent of subjects the chest condition is found to be satisfactory, of the remaining 5 per cent. some of the miniature radiographs will be shown to be technically unsatisfactory and in others confirmation of a pathological condition is necessary As repeat examinations are never made on a miniature film and interpretation of pathological appearances is not advisable on these small films, such examinees are recalled on technical grounds for large film examination When the large films are taken on the same unit, the exposure is again based on the chest thickness measurement and standard development is employed The results show a very high standard of quality and uniformity.

DEVELOPMENT

Development for the large films is also standardised; by using a replenisher it is possible to process 500 17-inch by 14-inch films in a 3-gallon tank of developer "topped up" with $3\frac{1}{2}$ gallons of replenisher

EXPOSURE TABLE FOR LARGE FILMS

(Postero-anterior position at 60 inches focus-film distance)

	†Chest Thickness	kVp	*(Stud)	Time in seconds at 300 mA
	6″	56	(2)	0.05
	6½″	56	(2)	0.06
	7″	58	(3)	0.06
	7½″	60·5	(4)	0.07
Exposures for average size subjects	**8″**	**62·5**	**(5)**	**0.07**
	8½″	**65**	**(6)**	**0.07**
	9″	**67**	**(7)**	**0.07**
	9½″	**69·5**	**(8)**	**0.07**
	10″	**71·5**	**(9)**	**0.07**
	10½″	71·5	(9)	0.09
	11″	71·5	(9)	0.1
	11½″	74	(10)	0.1
	12″	76	(11)	0.1
	12½″	78	(12)	0.1
	13″	80·5	(13)	0.1
	13½″	82·5	(14)	0.1

* These *stud* values apply only to the standard unit supplied for the National Scheme.

† Measurement taken over greatest thickness of chest as for the miniature radiographs, as shown on the individual record cards.

Develop in Blue Label developer for *five* minutes at 65 F.

NOTE—This exposure table is based on the use of Ilford Standard film. When using the fast Red Seal film the exposure technique may be modified by reducing kilovolts or time, or by a combination of both to give a total reduction of 50 per cent.

RECALL LARGE FILM EXAMINATIONS OTHER THAN POSTERO-ANTERIOR VIEWS

It is obvious that for the recall large film examinations other views than postero-anterior will be required from time to time and the necessary instructions are given during the viewing of the miniature radiographs. Again it has been found possible to work to the original thickness measurement, followed by standard development. The increase in kilovolts or/and exposure time being based on the exposure technique used for the original large film postero-anterior view.

This routine and standardised method of procedure for the taking of the large films is invaluable when many subjects have to be examined in the minimum of time, and when dark-room accommodation is inadequate as may well occur when the unit is taken to temporary premises.

ADJUSTMENTS IN EXPOSURE TECHNIQUE FOR LARGE FILMS OTHER THAN POSTERO-ANTERIOR VIEWS

These exposures are based on the technique used for the postero-anterior view of the lungs taken at 60 inches focus-film distance and in accordance with the chest thickness measurement.

1. ANTERO-POSTERIOR: Increase by 4 kilovolts on the conditions used for the postero-anterior view.
2. LATERAL: Increase by 20 kilovolts and 0·02 seconds on conditions used for the postero-anterior view.
3. LORDOTIC POSITION: At 48 inches focus-film distance, increase by 4 kilovolts on conditions used for postero-anterior view.
4. FOR HEART POSTERO-ANTERIOR: At 72 inches focus-film distance increase by 8 kilovolts on conditions used for postero-anterior view of lungs.
5. OBLIQUE RIGHT AND LEFT ANTERIOR: At 36 inches focus-film distance, increase by 4 to 6 kilovolts, as indicated by screen examination, on conditions used for the postero-anterior view of lungs.
6. OPACITY IN CHEST (tumours, dense fibrosis, fluid, etc.)
   (*a*) POSTERO-ANTERIOR: Using a stationary grid at 36 inches focus-film distance, increase by 4 to 8 kilovolts, according to the degree of opacity present and 0·03 second on the conditions used for the postero-anterior view of lungs.
   (*b*) LATERAL: At 36 inches focus-film distance increase by 20 kilovolts and 0·03 seconds on the conditions used for the postero-anterior view of the lungs.

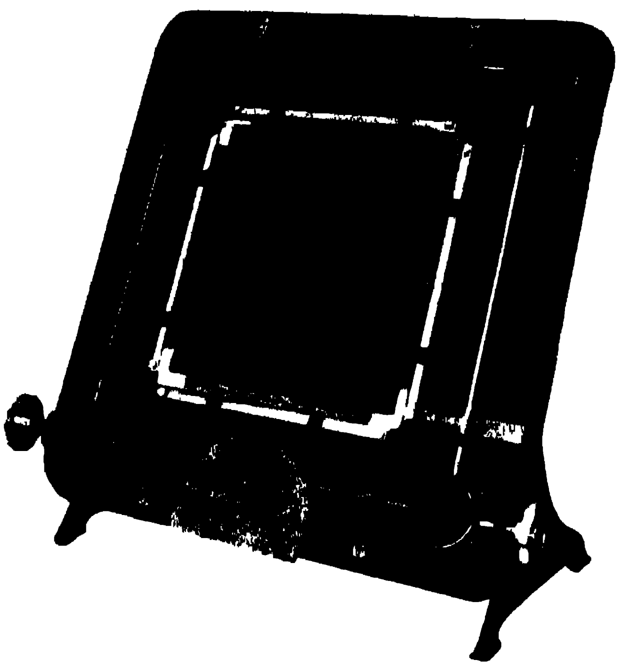
For small areas the aperture of the tube should be reduced to the smallest size and the region localised by screen examination.

SECTION 34

Seriescopy

SERIESCOPY

Only brief mention is made of this technique, which is closely related to Stereography and Tomography. It is a method whereby a series of films which have been exposed in a particular manner are placed one over the other on a specially constructed viewing box or *seriescope* **(1205)**, when each layer in the subject may be brought into focus and the depth registered on a calibrated dial. The visual effect is, therefore, that of progressing through the subject from surface to surface, and in "passing through" it is possible to bring any structure into sharp focus, to the exclusion, by diffusion, of all others.



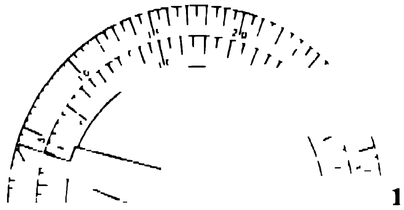
1205

The technical procedure is as follows:—

A cassette tunnel or Potter-Bucky diaphragm is employed to enable the films to be placed in position for exposure, one after the other, without disturbing the patient. Immobilisation is of great importance, and for chest work it is essential to employ a means of registering *and repeating* the phase of respiration *for each film*. Four films are employed; and to ensure their being correctly placed in the viewing box they are marked to show the order of exposure, and markers are placed on top of the cassette tunnel to indicate the common exposure position, the depth measurements recorded on the dial of the seriescope being registered from this level **(1206)**.

The tube is centred to the film and is then displaced a known distance from this point for each film in turn—transversely toward right (1), and left (2), and longitudinally, toward feet (3) and head (4) of the patient. For (1) and (2) the films are placed transversely, and for (3) and (4) lengthwise, to the patient.

The degree of displacement depends upon the anode to film distance employed, which in turn depends on the thickness of the region examined. For regions where a distance of 30 inches is suitable the tube is displaced 15 per cent. of this distance, or $4\frac{1}{2}$ inches, for each pair of exposures, the exposure points being $2\frac{1}{4}$ inches from the mid-centring point. At 60 inches the tube shift is 10 per cent. of that distance, 6 inches separating the exposure points, each of which is 3 inches from the mid-centring point. The requirements of general examinations and of chest investigations are met, respectively, by these anode-film distances, and the two depth scales with which the seriescope is fitted meet such conditions **(1206)**.



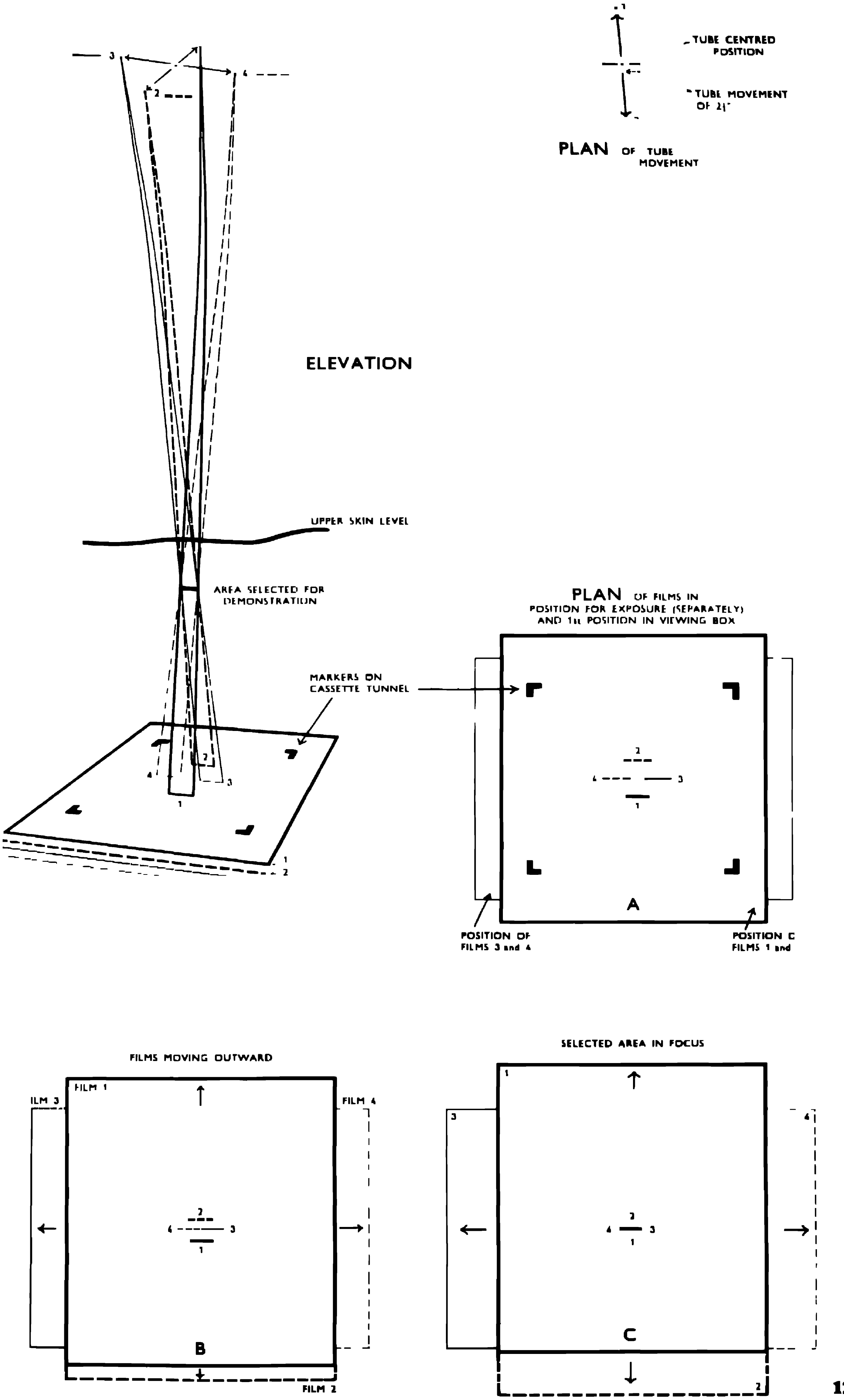
1206

Normal exposure technique must be modified in order that thin negatives may be produced, it being borne in mind that notwithstanding the brilliant illumination of the viewing box the films are to be placed one over the other to be viewed simultaneously, and thus present considerable density **(1205)**.

The diagram **(1207)** shows the projection of a small area of tissue at a depth of 2 inches, the appropriate position of each film being indicated by a distinct line. Although in the diagram the lines are shown one below the other, for actual exposure each film in turn occupies the same position in the cassette tunnel. A plan indication of the tube movement is shown beside the tube position in the elevation, with below it a plan (A) of the displaced shadows, which latter shows also the initial position of the films in the viewing box.

When the films are correctly placed in the seriescope their *outward* displacement (B) causes the shadows to move toward the centre point until they merge into a single image (C) which is in focus. Although for convenience only a small area of the selected plane is illustrated, it will be understood that each movement of the films in the seriescope brings other depth layers progressively into focus.

In the illustration of the seriescope **(1205)** four films are shown in the viewing position. These films, exposed at an anode-table-top distance of 30 inches, were taken of a phantom consisting of four pieces of wire mesh of varied aperture embedded in layers of paraffin wax, and the seriescope is shown adjusted to enable the wire of larger mesh, which was in the near table top position, to be in focus.



1207

A—B—C SHOW 3 POSITIONS OF FILMS IN VIEWING BOX

Opaque Media commonly employed in the British Isles for Radiographic Examinations

BARIUM SULPHATE

Specially prepared for X-ray purposes and employed in suitable suspension as a meal or enema.

APPLICATION

Œsophageal Meal or Bolus

Similar to the opaque meal, as given below, but prepared in much less fluid form—page 334.

Opaque Enema

Three pints of enema contains 8 ounces of barium sulphate in suspension—page 342.

Opaque Meal

One pint of the meal contains 4 ounces of barium sulphate: may be mixed with arrowroot or cornflour, or made with water and gum tragacanth and flavoured to taste. Supplied, ready for use, as Barium Cream, Shadow Meal, etc.—pages 332, 333, 336.

BISMUTH CARBONATE

Employed for opaque meals, but used only occasionally for infants, when up to one ounce is mixed with the ordinary bottle feed—page 350.

IODINE PREPARATION

An organic iodine compound containing 51·5 per cent. iodine. Supplied in 20 cubic centimetre sterile ampoules as Per-Abrodil, Pyelectan, Uropac, Uroselectan-B, etc. (Pyelectan for intravenous injection only.)

APPLICATION

Amniography

Injection into the amniotic sac: *diluted* with four times its volume of sterile distilled water—page 414.

Arteriography

Injection into the regional main artery for head and limbs: an *undiluted* solution as supplied in ampoule form, preparing up to 20 cubic centimetres—page 282.

Arthrography

Examination of joint capsules, preparing up to 3 cubic centimetres of *diluted* solution.

Urography

Cystography:—

By catheter injection, *diluted* with four times its volume of sterile distilled water, preparing up to 6 ounces—page 390.

Urography (*continued*)

Pyelography and Ureterography:—

(*a*) by intravenous injection, *undiluted*, preparing for an adult a 20 cubic centimetre ampoule; for a child aged 9 to 14 years 14 cubic centimetres; for a child aged 5 to 9 years 10 cubic centimetres; and for a child of less than 5 years only 7 cubic centimetres—page 384.

(*b*) by retrograde injection, *diluted* with four times its volume of sterile distilled water, preparing up to 20 cubic centimetres—page 388.

Urethrography:—

By syringe injection, *diluted* as in (*b*) above, preparing 12 cubic centimetres—page 392.

IODISED OIL

A 40 per cent. iodine compound with poppy-seed oil. Supplied in 5 cubic centimetre and 20 cubic centimetre sterile glass bottles, as Lipiodol, Neo-Hydriol, etc. May be heavy or light iodised oil, sometimes referred to as "descending" and "ascending" respectively: heavy iodised oil is usually employed.

APPLICATION

Bronchography

The iodised oil is introduced into the trachea to outline the bronchial tree, up to 20 cubic centimetres being prepared—page 320.

Cholangiography

Injection of a biliary fistula after a gall bladder operation for the purpose of outlining the hepatic ducts and common bile duct—page 371.

Cystography

Diluted with 10 times its volume of sterile olive oil, preparing from 4 ounces to 6 ounces for catheter injection—page 390.

Fistula

Biliary fistula, up to 10 cubic centimetres of iodised oil being prepared for injection into the fistulous tract—page 371.

Lacrimal Ducts

Up to 2 cubic centimetres prepared for injection into the lower puncta—page 244.

IODISED OIL *(continued)*

Empyema Cavities

20 or more cubic centimetres of iodised oil is prepared for injection and may be required *diluted*, 1 in 4 or 1 in 8, in liquid paraffin or olive oil—page 312.

Myelography

Injection into the sub-arachnoid and epidural spaces of the spinal cord, preparing up to 5 cubic centimetres—page 474.

Nasal Accessory Sinuses

Up to 8 cubic centimetres prepared for injection—page 242.

Sialography

Parotid Gland: up to 3 cubic centimetres prepared for injection *via* the parotid (Stenson's) duct—page 216.

Sinuses and Cavities

Up to 20 cubic centimetres prepared for injection—pages 352, 472.

Utero-Salpingography

From 10 cubic centimetres to 20 cubic centimetres prepared for injection—page 399.

Urethrography

Up to 12 cubic centimetres prepared for injection—page 392.

SODIUM IODIDE

A 10 per cent. to 20 per cent. solution, which is usually prepared in the hospital dispensary.

APPLICATION

Urography

Cystography:—

By catheter injection, up to 6 ounces being prepared—page 390.

Urography *(continued)*

Pyelography and Ureterography:—

By retrograde injection, up to 20 or more cubic centimetres being prepared—page 388.

SODIUM TETRAIODOPHENOLPHTHALEIN COMPOUND

Supplied as Opacol, Opacin, Shadocol, Stipolac, etc.

APPLICATION

Cholecystography

(*a*) Intravenous, employing Opacin. Supplied in ampoules. 1·75 grammes in 20 cubic centimetres of triple distilled water—page 369 (rarely employed).

(*b*) Oral. Supplied as a powder and mixed with water as required, 4 grammes in each bottle constituting an adult dose—pages 361, 368.

For (*a*) and (*b*) two-thirds only of the dye is given to children between the ages of 10 years and 14 years, and for children of less than 10 years from one-third to one-half of the full dose.

THORIUM-DIOXIDE

In colloidal suspension, supplied in 12 and 25 cubic centimetre sterile ampoules as Thorotrast.

APPLICATION

Arteriography

Injection into the regional main arteries for head and limbs, up to 20 cubic centimetres being prepared—page 282.

Hepato-lienography

Examination of liver and spleen following intravenous injection—page 355 (rarely applied).

NOTE.—It should be understood that all injection preparations should be used at body temperature.

SPECIAL NOTE.—For specific instructions in the application of the opaque media, reference should be made to the leaflets accompanying the preparations.

Note on the Exposure Tables

Examination of the radiographs which come to notice from day to day would seem to show that the wide range of flexibility of exposure technique is by no means widely appreciated, there being in many cases evidence that little advantage has been taken of the possibilities of balancing the values of the several component exposure factors.

The operation of modern apparatus has been reduced to very simple terms, but the essential adjustment of the apparatus to meet the conditions presented by the individual patient rests, as it must always rest, with the operator, and only by a full understanding of the factors at his disposal will he be able to make such adjustment and to produce radiographs of technical quality and good diagnostic value as a matter of routine, which is the purpose of every X-ray department. The qualified professional X-ray worker of to-day receives a careful training, and although the ability to make quick factor-exchange calculations is only acquired by experience of actual departmental work, no element of chance should be permitted to enter into the making of the radiograph.

It is fully appreciated that in many departments the greatest accuracy is observed: it follows that such departments will have compiled complete exposure data and will not normally refer to any other source. The beginner, however, and those less familiar with the many variants involving the whole range of materials and methods of application and control, will perhaps welcome some guidance, and to such the following notes may be of assistance.

Brief reference to exposure factors and to the exposure tables given is made in the Preliminary Note (pp. 6 and 7). It should be understood that the tables are included for guidance only, and that it is not possible to give more than relative data in each section in respect of a particular region.

There being, unfortunately, no standard of film quality and density for any specified region, the quality aimed at should be that most suitable to the requirements of the individual radiologist, which should present no difficulty, "film latitude" being so wide and accommodating in range.

The following are typical exposure tables, and an explanation is here given of each item.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
60	30	18	30 ins.	Ilfex	—	
50	60	36	30 ins.	Ilfex	—	
45	10	6	36 ins.	Ilford	Tungstate	

Cone to size of film, 6½ × 4¾ ins.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford	Grid
*65	57	35	36 ins.	Ilford	Tungstate	—
*75	76	46	36 ins.	Ilford	Tungstate	Stationary
75	200	120	48 ins.	Ilford	Tungstate	Potter-Bucky

Cone to size of film, 10 × 8 ins. or 12 × 10 ins.

* Ward mobile unit.

EXPOSURE FACTORS

kVp.	mA. Secs. Ilford X-ray	mA. Secs. Developers Blue Label	Distance	Film	Screens Ilford
60	18	15	36 ins.	Ilford	Tungstate
55	18	15	36 ins.	Ilford	Fluorazure

kVp. (kilovolts-peak). Kilovolts indicates the tension across the tube as controlled by the auto-transformer in the primary circuit of the high tension transformer, "peak" indicating the highest kilovoltage reached during a single impulse. An alternative term is "kilovolts R.M.S." (Root Mean Square), "R.M.S." indicating a mean value of the kilovoltage impulse curve as compared with the peak value. Obviously, kVp. is of a higher value than kV. R.M.S., the latter representing approximately

Note on the Exposure Tables (*continued*)

70 per cent. of the value of the former, as shown in the following table:—

kV. Peak	30	40	50	60	70	80	90	100
kV. R.M.S.	21	28	35	42	50	57	64	71

For the purpose of this note the term "kilovolts" should be read as meaning "kilovolts-peak."

The kilovoltage applied determines the degree of penetration of the rays, and also has a major influence on the quality of the radiograph. For the examination of the thicker parts of the body, involving greater penetration, the higher values are employed. The higher values are also applied where widely varying regional densities would otherwise give the black and clear film, lacking detail, which is of little or no diagnostic value: by the use of the higher kilovoltage the hard contrast is reduced, and a softer, flatter result obtained.

The practical range employed is from 55 to 85 kilovolts. An approximate density exchange between kilovolts and exposure, in time or milliampere-seconds, is obtained by increasing the kilovoltage value by 10 and applying only *half* the original exposure: conversely, a kilovoltage reduction of 10, balanced by *doubled* exposure, would give a result of similar density. This degree of exchange is, however, approximate only, and should not be applied when the value is appreciably more than 80, or appreciably less than 60, kilovolts.

mA. Secs. (*milliampere-seconds*) is the value of the product of the applied high tension current in milliamperes and the duration of exposure in seconds. These two factors—milliamperes and time—are quoted in this form to cover the many milliamperages used according to departmental requirements, the maximum milliamperage employed being obviously governed by tube limitations although not necessarily being the maximum rated output of the tube. It is obvious that by dividing the milliampere-seconds (mA. Secs.) quoted in the tables by the milliamperage to be applied in any case the appropriate exposure time in seconds is indicated.

The following milliamperages are those generally employed by the writer.

Limbs. Without intensifying screens, 40 or 80 milliamperes: with screens, 10 milliamperes.

Skull, Spine, Pelvis and Hip. 40 or 80 milliamperes.

Heart and Lungs. Maximum milliamperage available according to tube employed: 6 K.W. tube, 100 to 150 milliamperes: rotating anode tube, 1·2 × 1·2 mm. focus, 250 milliamperes.

Alimentary Tract. 100 milliamperes, applying high kilovoltage and short exposure time.

Gall Bladder. 100 milliamperes (employing short exposure time).

Urinary Tract. 80 to 100 milliamperes.

Dental. On dental unit, 8 milliamperes (distance 9 inches): on mobile and four-valve units, 20 milliamperes (distance 20 inches).

Screening. 4 milliamperes, 70-80 kilovolts.

Ilford Developers	
X-ray	Blue Label
80	48
132	80

Developers. Two mA. Secs. values are given, one for each of the two types of developer named—Ilford X-ray Developer, a standard developer particularly suitable for Ilford X-ray films, and Ilford Blue Label Developer, which is much used owing to its speed and long life and to its production of high contrast, radiographically, which allows of the employment of a relatively higher kilovoltage with a corresponding further reduction of exposure time. Compared with the standard Ilford X-ray developer the use of Ilford Blue Label developer enables the exposure time to be reduced by as much as 40 per cent., and it is therefore of value when small-output mobile and portable units are employed. It should be noted also that instead of the reduced exposure time a lower kilovoltage, or shorter developing time of only three minutes, may be applied. For the factors quoted in this book, *standard development* was employed throughout, that is, 5 minutes at 65 degrees F., using freshly made developer.

To obtain standard results as the developer deteriorates it is advisable to *maintain normal exposure time* and to *increase the developing time.* When, however, regeneration of the developer is applied, the conditions of such regeneration should be most carefully controlled in order that standard developing time may be adhered to.

Short processing time is of importance when radiographs are taken during an operation; and the use of Ilford Rapid Radiographic (15 seconds) Developer and Ilford Quick Fixing Salts, briefly referred to in the first edition, enables radiographs to be viewed within one minute of the exposure.

Distance indicates the anode-film distance employed. This may, of course, be adjusted according to the apparatus used and to the routine of the department, the appropriate exposure time being calculated by applying the following formula:—

$$\frac{\text{New distance squared}}{\text{Original distance squared}} \times \text{Original exposure} = \text{New exposure.}$$

Note on the Exposure Tables (*continued*)

Films. Under this heading is given Ilford X-ray film for use with or without intensifying screens; Ilfex, a non-screen film 25 per cent. faster than the last named, giving high contrast and fine definition, and being particularly suitable for bone work; Ilford X-ray Dental film, both "standard" and "contrast", the former requiring only one-fifth of the exposure required for the latter but at the same time maintaining a high degree of contrast and definition; and Occlusal, either double-wrapped or for use with intensifying screens. In quoting exposure technique it is just as important to quote the type and make of film as to indicate other factors. The size of film employed for each position is given as a suggestion only.

Complete exposure data for the use of X-ray Paper, which was not mentioned in the first edition, have been included in the second edition. Briefly, the exposure conditions are generally similar to those required for film, a slightly lower kilovoltage being employed, with a correspondingly increased exposure time.

Intensifying screens include Ilford Calcium Tungstate and Fluorazure (Zinc Sulphide), the former being a medium speed screen of high definition value, and the latter, Fluorazure, having two to three times the speed of the Tungstate screen. Exposure factors for Ilford High Definition Screens have been included in the second edition: these screens require rather less than twice the exposure required for Ilford Tungstate, the reduction in speed being well compensated for by the improved definition value. Here again it is essential to quote both type and make of screens when precise information is given or required. The following table shows the relative speeds of Ilford films and screens when exposed at kilovoltages varying from 40 to 90.

	Speed of Ilford X-ray Films and Paper when used *with* Ilford Intensifying Screens			Speed of Ilford Films when used *without* Intensifying Screens	
kVp.	Tungstate	Fluorazure	High Definition	Ilfex	Ilford X-ray
40	1	0·3	2	10	13
50	1	0·4	2	14	18
70	1	0·5	2	17	22
90	1	0·7	2	23	30

It is advisable that all intensifying screens in the one department should be tested for relative speed and marked accordingly, as screens differing in age and make may be found to have greatly differing characteristics.

The *radiographic grids* include the Potter-Bucky diaphragm and the Stationary and Moving Lysholm grids. Using the former the relative non-grid exposure should be multiplied by four, while for the latter the multiple should be three or, for the all-metal grid, as much as four. Here again the grid factor is an important constituent of exposure technique.

The use of a *localising cone* of minimum diameter applicable to the size of film employed or the limiting of the aperture of the rectangular diaphragm is imperative, both as a protective measure and as an aid to definition: this, too, is a factor to be considered in exposure technique, especially when estimating, usually in terms of kilovoltage, the exposure required for a large or a small area, such as general abdomen or duodenum, the latter requiring an added 15 to 20 kilovolts, or the equivalent in mA. secs., particularly when the grid is not employed.

The asterisk in the tables indicates the use of a unit other than the fully rectified four-valve—for example, the 15 or 30/90 mobile, or the 10 milliampere dental units. Such units were compared for kilovoltage output, the four-valve unit, specially calibrated for the purpose, being taken as a standard.

Subject. The factor of the *patient* is the most variable of all and must govern the technique employed. Here must be considered the region of examination, age (child, adult, old person), thickness and condition of tissues (muscular, flabby, pathological), and the presence of plaster or other splints and of dressings.

The exposure technique was selected throughout for subjects of average size. Early in each section mention is made of the actual type and size of subject to which the particular exposure factors apply, and it is suggested that for larger or smaller subjects the exposure be varied by from 25 per cent. to 50 per cent. as applied to milliampere-seconds, or by 5 to 10 kilovolts.

A complete set of exposures for the section concerned was made on the subject whose data are given, and such exposures were confirmed by their application to a number of similar subjects. The exposures given are, therefore, relatively correct for that particular section and subject when *all* factors are given due consideration.

Mention was not made of *viewing box illumination* in the first edition. It is obvious that the degree of illumination is of importance when judging film quality and density. The films referred to were viewed on a Pyramid Type Viewing Lantern (Royal Cancer Hospital Pattern) supplied by Ilford Limited, which lantern is specially designed to give the necessary brilliant illumination.

Selected Exposure Technique for a Mobile Unit

This exposure table is suitable for an adult subject weighing 160 lbs. and of height 5 feet 9 inches, employing a mobile X-ray unit having a maximum output of 85 kilovolts and 25 milliamperes.

REGION	POSITION	NUMBER IN TEXT	kVp.	mA.	TIME IN SECONDS Ilford X-ray	Developers Blue Label	DISTANCE IN INCHES	STATIONARY GRID
Employing Ilfex Non-Screen Film:								
HAND	Postero-anterior	5	60	20	2	$1\frac{1}{4}$	30	
	Lateral	7	60	20	$3\frac{3}{4}$	$2\frac{1}{4}$	30	
	Oblique	9	60	20	$2\frac{1}{2}$	$1\frac{1}{2}$	30	
WRIST AND LOWER FOREARM	Postero-anterior	29	60	20	2	$1\frac{1}{4}$	30	
	Lateral	37	60	20	4	$2\frac{1}{2}$	30	
	Oblique	44	60	20	$2\frac{3}{4}$	$1\frac{3}{4}$	30	
ELBOW, UPPER FOREARM AND LOWER ARM	Antero-posterior	64	60	20	$3\frac{1}{4}$	2	30	
	Lateral	58	60	20	$3\frac{1}{4}$	2	30	
ELBOW, FLEXED	Antero-posterior	71	60	20	4	$2\frac{1}{2}$	30	
FOOT	Dorsi-plantar oblique	149	70	20	$1\frac{1}{2}$	1	30	
	Dorsi-plantar	155	70	20	$1\frac{1}{2}$	1	30	
	Oblique	158	70	20	$2\frac{1}{4}$	$1\frac{1}{2}$	30	
	Lateral	160	70	20	$3\frac{1}{4}$	2	30	
ANKLE AND LOWER HALF OF LEG	Antero-posterior	183	60	20	$4\frac{1}{2}$	$3\frac{1}{2}$	30	
	Lateral	188	60	20	$3\frac{1}{4}$	2	30	
OS CALCIS	Axial (Patient supine)	176	80	20	$6\frac{1}{2}$	4	30	
Employing Ilford X-ray Film and Ilford Calcium Tungstate Intensifying Screens:								
KNEE, UPPER HALF OF LEG AND LOWER HALF OF FEMUR	Antero-posterior	197	60	20	1	$\frac{5}{8}$	36	
	Lateral	209	60	20	$\frac{3}{4}$	$\frac{1}{2}$	36	
PATELLA	Postero-anterior	203	60	20	$1\frac{1}{2}$	1	36	
SHOULDER	Antero-posterior	101	60	20	$1\frac{3}{4}$	$1\frac{1}{8}$	30	
CLAVICLES	Antero-posterior	120	60	20		$1\frac{1}{4}$	30	
SCAPULA	Lateral	115	70	20	4	$2\frac{1}{2}$	30	Grid
HIP AND UPPER HALF OF FEMUR	Antero-posterior	237	70	20	$6\frac{1}{2}$	4	30	Grid
	Lateral	240	70	20	$6\frac{1}{2}$	4	30	Grid
	Lateral (Patient supine)	245	75	20	$7\frac{1}{4}$	$4\frac{1}{2}$	30	
NECK OF FEMUR	Lateral	266	85	20	$3\frac{1}{4}$	2	28	

REGION	POSITION	NUMBER IN TEXT	kVp.	mA.	TIME IN SECONDS Ilford X-ray	TIME IN SECONDS Developers Blue Label	DISTANCE IN INCHES	STATIONARY GRID
Employing Ilford X-ray Film and Ilford Calcium Tungstate Intensifying Screens (continued)								
PELVIS	Antero-posterior	294	70	20	6½	4	30	Grid
CERVICAL SPINE	Antero-posterior, 1–3	328	55	20	3¼	2	30	—
	Antero-posterior, 2–7	336	55	20	2	1¼	30	—
	Lateral, 1–7	342	60	20	5	3	60	—
DORSAL SPINE	Antero-posterior	361	80	20	4⅛	2½	30	Grid
	Lateral	368	80	20	5	3	30	Grid
LUMBAR SPINE	Antero-posterior and Postero-anterior	391	70	20	6½	4	30	Grid
	Lateral	389	82	20	11 (*interrupted exposure*)	7	30	Grid
SKULL, GENERAL	Lateral	488	70	20	2	1¼	30	Grid
	Postero-anterior (Occipito-frontal)	496	70	20	3¾	2¼	30	Grid
OCCIPUT	30° Antero-posterior (30° Fronto-occipital)	504	70	20	4⅛	2½	30	Grid
FACIAL BONES	Postero-anterior (Occipito-mental)	530	80	20	3¾	2¼	30	Grid
	30° Postero-anterior (30° Occipito-mental)	534b	80	20	3¾	2¼	30	Grid
	Lateral	536	70	20	1¼	¾	30	Grid
MANDIBLE	General	570	60	20	¾	½	30	—
CHEST	Postero-anterior	826	70	20	½	¼	60	—
	Postero-anterior	814	60	20	¼	⅛	30	-
	Lateral	835	80	20	¼	⅛	30	
	Oblique	841	70	20	½	¼	30	—
RIBS	Oblique	459	65	20	1¼	¾	30	—
ABDOMEN	Postero-anterior	932	70	20	—	3	30	Grid
	Lateral	933	82	20	—	5½	30	Grid
	Postero-anterior	932	70	20	1½	1	30	—
	Lateral	933	82	20	3	2	30	—

Selected Exposure Technique for a Mobile Unit (Tube undercouch)

This exposure table is suitable for an adult male subject of average physique, employing a mobile unit with an output of 75 kilovolts-peak, and 15 milliamperes.

REGION	POSITION	TIME IN SECONDS — Ilford Developers — X-ray	TIME IN SECONDS — Ilford Developers — Blue Label	DISTANCE IN INCHES	STATIONARY GRID
Employing Ilfex Non-Screen Film					
HAND AND WRIST	Antero-posterior	$\frac{1}{5}$	$\frac{2}{5}$	20	—
	Lateral	$1\frac{1}{5}$	$\frac{4}{5}$	20	—
ELBOW	Postero-anterior	$\frac{1}{5}$	$\frac{2}{5}$	20	
	Lateral	$\frac{4}{5}$	$\frac{2}{5}$	20	—
ANKLE	Antero-posterior	2	$1\frac{1}{5}$	20	–
	Lateral	$1\frac{2}{5}$	$\frac{4}{5}$	18	
KNEE	Postero-anterior	$3\frac{1}{5}$	2	23	-
	Lateral	$2\frac{1}{5}$	$1\frac{2}{5}$	20	-
Employing Ilford X-ray Films and Ilford Calcium Tungstate Intensifying Screens:					
SHOULDER	Postero-anterior	$\frac{1}{5}$	$\frac{2}{5}$	22	—
	Postero-anterior	1	$\frac{1}{5}$	22	Grid
HIP	Antero-posterior	$4\frac{1}{5}$	3	22	Grid
	Antero-posterior	$1\frac{3}{5}$	1	22	—
PELVIS	Antero-posterior	$1\frac{2}{5}$	$\frac{4}{5}$	22	—
CERVICAL SPINE	Antero-posterior, 1–3	$1\frac{2}{5}$	$\frac{4}{5}$	23	Grid
	Antero-posterior, 2–7	1	$\frac{1}{5}$	22	Grid
DORSAL SPINE	Antero-posterior	3	$1\frac{1}{5}$	22	Grid
	Lateral	$6\frac{1}{5}$	4	27	Grid
LUMBAR SPINE	Antero-posterior	$1\frac{2}{5}$	$\frac{1}{5}$	22	—
	Antero-posterior	$4\frac{1}{5}$	$2\frac{2}{5}$	22	Grid
	Lateral	11 (interrupted exposure)	$3\frac{1}{2}$	25	—
SKULL	Lateral	$\frac{1}{5}$	$\frac{2}{5}$	20	—
	Lateral	$1\frac{4}{5}$	$1\frac{1}{5}$	20	Grid
	Postero-anterior (Occipito-frontal)	$1\frac{1}{5}$	1	20	—
	Postero-anterior (Occipito-frontal)	$4\frac{4}{5}$	3	20	Grid
	30° Antero-posterior (30° Fronto-occipital)	$5\frac{4}{5}$	$3\frac{1}{2}$	22	Grid
CHEST (tube head removed from couch)	Postero-anterior	1	$\frac{2}{5}$	48	—
RIBS, UPPER	Antero-posterior	$\frac{2}{5}$	$\frac{1}{4}$	22	—
Employing Ilford X-ray Films and Ilford Fluorazure Intensifying Screens:					
LUMBAR SPINE	Lateral	$5\frac{3}{4}$	$3\frac{1}{2}$	25	—
	Lateral	—	10 (interrupted exposure)	25	Grid

NOTE—These exposure factors will be found to be satisfactory when fresh developer is employed for 5 minutes at a temperature of 65 degrees Fahrenheit.

Selected Exposure Technique for X-ray Paper

This exposure table is suitable for an adult subject of average physique, using Ilford X-ray Paper and employing a four valve X-ray unit, Ilford Calcium Tungstate Intensifying Screens, and processing with Ilford X-ray Developer for 5 minutes at a temperature of 65 degrees Fahrenheit.

REGION	POSITION	NUMBER IN TEXT	kVp.	mA	TIME	DISTANCE IN INCHES	POTTER-BUCKY DIAPHRAGM
HAND	Postero-anterior	5	45	40	$\frac{2}{5}$	36	—
	Lateral	7	45	40	$\frac{4}{5}$	36	
	Oblique	9	45	40	$\frac{1}{2}$	36	—
WRIST AND LOWER FOREARM	Postero-anterior	29	45	40	$\frac{2}{5}$	36	—
	Lateral	37	45	40	$\frac{4}{5}$	36	—
	Oblique	44	45	40	$\frac{1}{2}$	36	
ELBOW, UPPER FORE-ARM AND LOWER ARM	Antero-posterior	64	45	40	$\frac{1}{5}$	36	—
	Lateral	57	45	40	$\frac{1}{5}$	36	—
ELBOW, FLEXED	Antero-posterior	71	50	40	$\frac{1}{5}$	36	—
SHOULDER AND CLAVICLE	Antero-posterior	101	45	40	$1\frac{9}{10}$	36	—
SCAPULA	Lateral	115	55	40	3	36	P.B.
FOOT	Dorsi-plantar oblique	149	45	40	$\frac{4}{5}$	36	—
	Dorsi-plantar	155	45	40	$\frac{4}{5}$	36	—
	Oblique	158	45	40	1	36	—
	Lateral	160	45	40	$1\frac{1}{5}$	36	—
ANKLE AND LOWER HALF OF LEG	Antero-posterior	183	45	40	$\frac{1}{5}$	36	—
	Lateral	188	45	40	$\frac{1}{2}$	36	—
OS CALCIS	Axial (Patient supine)	176	60	40	$\frac{1}{4}$	36	—
KNEE, UPPER HALF OF LEG AND LOWER HALF OF FEMUR	Antero-posterior	197	45	40	1	36	—
	Lateral	209	45	40	$\frac{3}{4}$	36	—
PATELLA	Postero-anterior	203	45	40	$1\frac{1}{4}$	36	
HIP AND UPPER THIRD OF FEMUR	Antero-posterior	237	60	80	$2\frac{1}{2}$	30	P.B.
	Lateral	240	60	80	$2\frac{1}{2}$	30	P.B.
PELVIS	Antero-posterior	294	60	80	$2\frac{1}{2}$	30	P.B.
CERVICAL SPINE	Antero-posterior, 1–3	328	55	40	1	30	
	Antero-posterior, 2–7	336	55	40	$\frac{4}{5}$	30	—
	Lateral, 1–7	342	60	80	$\frac{3}{4}$	60	—
DORSAL SPINE	Antero-posterior	361	65	80	3	30	P.B.
	Lateral (quiet respiration)	368	65	20	8	30	P.B.
CERVICO-DORSAL SPINE	Antero-posterior	349	65	80	$\frac{4}{5}$	30	P.B.

REGION	POSITION	NUMBER IN TEXT	kVp.	mA.	TIME	DISTANCE IN INCHES	POTTER-BUCKY DIAPHRAGM
LUMBAR SPINE	Antero-posterior and Postero-anterior	391	65	80	2	30	P.B.
	Lateral	389	70	80	3	30	P.B.
SKULL, GENERAL	Lateral	488	54	80	2	30	P.B.
	Postero-anterior (Occipito-frontal)	496	60	80	$2\frac{1}{2}$	30	P.B.
OCCIPUT	30 Antero-posterior (30 Fronto-occipital)	504	60	80	$2\frac{3}{4}$	30	P.B.
CHEST	Postero-anterior	826	62	200	$\frac{1}{10}$	60	-
	Lateral	835	75	200	$\frac{1}{10}$	48	
ABDOMEN	Postero-anterior	932	65	80	$1\frac{3}{4}$	30	P.B.
	Lateral	933	70	80	3	30	P.B.

NOTE—The *exposure technique for Ilford X-ray Paper* is a modification of that required for Ilford X-ray Film, the total exposure being similar but generally with a small interchange between kilovoltage and time or milliampere-seconds, there being a tendency to lower the kilovoltage.

In placing X-ray Paper in the cassette care should be taken to ensure that the resulting anatomical viewing position will be correct. X-ray Paper is coated on one side only and, therefore, only *one* intensifying screen—that in contact with the emulsion surface of the paper will be effective, the effect of the second screen—that in contact with the back of the X-ray Paper being negligible. The front screen is employed for the antero-posterior position of the subject and the back screen for the postero-anterior position. It is advisable to have a number of cassettes clearly marked "A.P." and some "P.A.", with the paper packed in the correct position facing toward front and back screen, respectively. To obtain uniformity of exposure, it is advisable to leave the two screens in the cassette. X-ray Paper negatives are usually viewed by reflected light, but they may also be viewed by strong transmitted light as for films.

Note on Non-screen Grid Technique

The use of the Potter-Bucky diaphragm or other form of grid in conjunction with the Ilfex Film (non-screen), which is at present applied chiefly for extremity work, is of value to improve definition and contrast by the elimination of scattered radiation, particularly in regions requiring comparatively high penetration, such as knee joint and thigh; and the following exposure factors for shoulder and limbs are given for the guidance of those interested in the development of this branch of non-screen film technique.

This exposure table is suitable for an adult subject of average physique, employing Ilfex Films with the Potter-Bucky diaphragm and processing, with Blue Label Developer under standard conditions.

REGION	kVp.	mA. SECS.	DISTANCE IN INCHES
HAND			
Postero-anterior	60	60	30
Oblique	60	80	30
Lateral	60	120	30
WRIST			
Postero-anterior	60	80	30
Lateral	60	140	30
FOREARM			
Antero-posterior	60	100	30
Lateral	50	150	30
ELBOW			
Antero-posterior	60	120	30
Lateral	60	120	30
FOOT			
Dorsi-plantar	70	60	30
Oblique	70	70	30
Lateral	70	100	30
ANKLE			
Antero-posterior	80	60	30
Lateral	70	70	30
KNEE			
Antero-posterior	70	180	30
Lateral	70	140	30
FEMUR, LOWER TWO-THIRDS			
Antero-posterior	80	200	30
Lateral	80	160	30

Metric Equivalents of Dimensions and Quantities

Inches	Centimetres	Inches	Centimetres
$\frac{1}{8}$	·317	8	20·320
$\frac{1}{4}$	·635	$8\frac{1}{2}$	21·590
$\frac{1}{2}$	1·270	$8\frac{3}{4}$	22·225
$\frac{3}{4}$	1·905	9	22·860
1	2·540	$9\frac{3}{4}$	24·765
$1\frac{1}{4}$	3·175	10	25·400
$1\frac{1}{2}$	3·810	$10\frac{1}{2}$	26·670
$1\frac{5}{8}$	4·127	$10\frac{3}{4}$	27·305
$1\frac{3}{4}$	4·445	11	27·940
2	5·080	$11\frac{1}{4}$	28·575
$2\frac{1}{4}$	5·715	12	30·480
$2\frac{1}{2}$	6·350	$12\frac{1}{2}$	31·750
$2\frac{3}{4}$	6·985	14	35·560
3	7·620	15	38·100
$3\frac{1}{2}$	8·890	16	40·640
4	10·160	$16\frac{1}{2}$	41·910
$4\frac{3}{4}$	12·065	18	45·720
5	12·700	20	50·800
$5\frac{1}{10}$	12·954	24	60·960
$5\frac{1}{8}$	13·017	25	63·500
$5\frac{1}{4}$	13·335	26	66·040
$5\frac{1}{2}$	13·970	28	71·120
6	15·240	30	76·200
$6\frac{1}{2}$	16·510	33	83·820
$6\frac{7}{8}$	17·462	35	88·900
7	17·780	36	91·440
$7\frac{3}{4}$	19·685		

Metric Equivalents of Dimensions and Quantities (*continued*)

Inches	Metres
40	1·02
42	·07
44	·12
48	·22
50	·27
54	·37
56	·42
60	·52
66	·68
72	·83

Feet & Inches			Metres
5			·65
5	7	=	·70
5	8	=	1·73
5	8½	=	1·74
5	9		1·75
5	10	=	1·78
5	11	=	1·80
8	0		2·44
12	0	=	3·66
20	0		6·10
22	0	=	6·71

Pounds		Kilos
125	=	56·70
140		63·50
146	=	66·22
150		68·04
157	=	71·21
160		72·57
168	=	76·20

Fluid Ounces		Cubic Centimetres
2		56·8
3	=	85·2
4	=	113·6
6		170·4
20		568·0

Approximate X-ray Film Sizes

GENERAL PURPOSE FILMS

English Inches	Continental Centimetres
4¼ × 3¼	9 × 12
6½ × 4¾	13 × 18
8½ × 6½	18 × 24
10 × 8	
12 × 6	15 × 30
12 × 10	24 × 30
12 × 12	30 × 30
14 × 14	35·5 × 35·5
17 × 7	15 × 40
15 × 12	30 × 40
17 × 14	35·6 × 43·2

DENTAL FILMS

	Inches	Centimetres
No. 01.	1¼ × 1	2·5 × 3
No. 2.	2¼ × 1½	4 × 5·6
No. 3.	3 × 2¼	5·7 × 7·5
No. 5.	1⅝ × 1¼	3 × 4